Industrial Organization and Management

THIRD EDITION

Industrial Organization and Management

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to my grandson **Davis Currier Palmer**

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• Preface

A world war has been fought since the previous edition of this book. The postwar period has been marked by economic, political, and social turmoil throughout the world. It has been a period of continuous inflation, for the most part. The effects of such inflation have been neutralized, to a considerable degree, by various means. Research is now a major function in American industry. The rate of mechanization of manufacturing operations and other forms of technological progress has increased greatly. More effective and economical methods of mass marketing have been developed. Some significant changes in the sources and methods of financing current and long-range manufacturing plans have taken place. These and other developments have made it possible for American industry to contribute greatly to a continuous improvement in the standard of living of the American people.

A most significant development has been the changes in the attitude of the executives of large business organizations toward their work. They have developed a more fundamental, mature, and thoughtful attitude toward the mission of the business organization. More and more business executives have accepted the increasing economic, political, and social responsibilities of executive leadership in a dynamic, industrial society. Large numbers of executives everywhere have participated in executive development programs of all kinds. They have recognized their obligation to readjust themselves to greater responsibilities during times of rapid growth and change. Executives and management educators have continued the development of a sound philosophy of management. Such a philosophy is the basis for effective thinking in the solution of business problems. It is necessary for a satisfactory integration of the personal objectives of owners and employees with the broad objectives of our society.

These events have not changed the fundamentals of good management, of course. Fundamental principles do not change with wars, inflation, social fads, or political administrations. They can merely be distorted through unintelligent or selfish misapplications. There have been many significant changes in management policies and practices during this period, however.

This edition attempts to record, analyze, and evaluate some of the more important changes in executive thinking and practices that have resulted. It deals chiefly with operative management in industrial establishments. The problems of administrative management have been discussed generally, by this author, in *The Fundamentals of Top Management*. *Industrial Organization and Management* shows the relationships between operative and administrative management, however. This is necessary because current operations in well-managed companies are largely an effect of long-range administrative planning, which is adjusted currently to accommodate changing conditions.

Previous editions of this book have served the industrial executive as well as the student of management. The book emphasizes, accordingly, fundamental objectives, policies, and general methods of approach to the solution of business problems. It is hoped that this emphasis will help the instructor of undergraduate students of management. He is responsible for the initial training of future executives in effective thinking concerning management problems. Such students usually lack practical experience with the work of management. For this reason, the present edition has been profusely illustrated and supported with examples of management practice. The examples have been taken from the practices of a wide variety of manufacturing companies in order to avoid emphasis on "system." This book does not advocate any particular "system." The best method, as far as this author is concerned, is the one that produces a maximum of results with a minimum of expense in the least time that is practicable. The practicing executive will find in this book many of the approaches to the solutions of management problems that have been used successfully in many manufacturing companies. These should aid his thinking when dealing with a specific difficulty that is affecting currently the operations of his company.

The author wishes to express his great appreciation for the helpful advice and constructive criticism that was given to him by his colleagues in the College of Commerce and Administration of The Ohio State University. He is particularly indebted to Dr. T. N. Beckman, Dr. James Davis, Dr. E. F. Donaldson, Dr. C. B. Hicks, Dr. M. J. Jucius, Dr. W. E.

Schlender, and Dr. R. S. Stockton of the Department of Business Organization. Dr. Schlender wrote many of the case problems found at the end of each chapter. Mr. Lester Fuszara of this Department revised the bibliography and the index. Dr. Harry Wolfe, of the Colgate-Palmolive Company, read the chapter "The Marketing of Manufactured Goods." Mr. Phil Carroll, professional engineer, read much of the chapter on "Motion and Time Study." A great many industrial companies have contributed valuable information and illustrative material to the production of this book. Some of it could not be used directly; all of it is appreciated. It is regretted that the list of companies is too long to permit individual acknowledgments.

My colleagues in the teaching profession will agree, I am sure, that the production of a manuscript is a trying experience for all concerned. I am most grateful for the patience of my wife, Dorothy O'Neil Davis, and my daughter, Dannette Davis Palmer. It is doubtful that this revision could have been completed without their coöperation in reading proof and in many other such tasks.

RALPH CURRIER DAVIS

Columbus, Ohio.
January 16, 1957.

Industrial Organization and Management

CHAPTER 1 •

• The Development of Modern Management

The Beginnings of Modern Industry

MEN had begun to associate in religious, military, political, economic, and social enterprises before the dawn of written history. Primitive organizations were small and crude. They became larger and more complex as man progressed through the hunting and fishing, pastoral, and agricultural stages in his development. The relations between individuals and groups became more complex. Their environment changed greatly. The motives underlying these relations seem to have persisted nevertheless. As archaeologists bring to light the records of ancient civilizations, we have no difficulty in understanding and appreciating the likes and dislikes, hopes, and ambitions of people who lived thousands of years ago.

The patterns of human behavior have been modified greatly by the changes that have taken place in our economic and social environment. These changes include the use of large aggregations of capital, the widespread use of machinery, greatly increased per capita production, mass production and distribution, a minute division of labor, and other social and economic developments. They have had far-reaching and immediate effects on our ideas and customs, and therefore on our methods of doing business. The executive or student of business has a more immediate and direct interest in the industrial stage of man's economic development. Nevertheless, some important problems of business organization and operation have a long history whose lesson should not be overlooked.

Large aggregations of labor were often brought together at one place, in ancient times, for manufacturing purposes. The resulting establishments may be regarded as factories, but not in the sense that we use the term today. They were generally aggregations of craftsmen. The divisions of labor took place on craft lines. Within the limits of a craft division, the journeyman worked his material into its completed form. This is different

from the division of labor in modern industry. The product is now broken down into assemblies and subassemblies of its component parts. The work of making each part is broken down into a great many successive steps or operations. Each of these operations may constitute the regular work assignment or job for a workman or group of workmen. Some of these operations may require considerable skill and knowledge. Others may require almost none. The older craft lines tend to disappear under such conditions. New skill and knowledge requirements are usually created, however. The causes of these changes in the conditions of labor and manufacture are related directly to the evolution of our industrial economy.

The Industrial Revolution

The industrial stage of man's development is usually considered to have begun with the Industrial Revolution. This term is commonly used to designate approximately the 20-year period from 1765 to 1785. Within this period, certain fundamental changes in methods and conditions of manufacture took place in the English textile industry. The effects of these changes on this industry, and eventually on all industry, were revolutionary. The social and economic forces generated by them have never ceased to act. The Industrial Revolution has been and still is a continuing phenomenon in consequence. A brief examination of these forces is necessary for a proper understanding of modern management problems.

The development of the steam engine by James Watt may be said to have ushered in the Industrial Revolution. This took place around 1765, although Watt did not receive his patents until a few years later. Steam engines had been invented and used prior to this time. It remained for Watt, however, to bring them to a satisfactory degree of efficiency. The evolution of an efficient prime mover was a requisite for the development of an industrial economy. Most of the developments that characterize such an economy depend on an ability to produce, distribute, and apply power in quantities at a distance. Watt's contribution has been followed by further improvement of the steam engine, the development of steam and hydraulic turbines, the invention and development of the internal combustion engine, generators and motors for the production and use of electric energy, high-tension transmission lines, and many other advances in the field of power production and distribution. The jet engine is our newest device for power production. The atomic engine is just over the next hill.

A series of inventions in the English textile industry came shortly after Watt's development. They covered a period of 15 years, approximately, from 1770 to 1785. The spinning jenny, invented by Hargreave, resulted in the saving of much hand labor in the spinning of yarn. Arkwright applied water power in a spinning device called the water frame. This was followed by Crompton's "mule" spinner, which embodied the features of both previous inventions. Finally, Cartwright invented his power loom for weaving cloth. The immediate effects of these inventions were unemployment, want, and privation. The substitution of machine for hand labor destroyed much of the need for existing craft skills. The journeymen in the industry suffered a permanent loss of earning power. A long, arduous apprenticeship of seven or eight years, plus many years of practical experience, had been required for their development. There was much rioting and sabotage of the new machinery by workmen in consequence. The Industrial Revolution furnished the first notable case of unemployment resulting from technological progress. It contributed to the development of what might be called a "work-fund" theory of labor, based on the concept that there is only so much work to be done; that there is less work to be divided among the workmen if labor is saved by machinery or other means. The short-time effects of mechanization may appear temporarily to support such a notion. The concept has no validity, nevertheless. The long-time effects have been to increase both the demand for labor, and real wages. The base of distribution has been broadened through reductions in costs and eventually in prices. More mechanics have been needed to build the machines, service them, and make the tools that these machines use. New service industries develop. General living standards are increased in the long run, provided that the fruits of technological progress are distributed widely through the competitive process. A rising standard of living requires increasing *per capita* production. The latter requires increasing mechanization. This depends on an increasing application of productive capital.

The mechanization of work results in some transfer of skill and intelligence from the man to the machine, causing what has been called "the degradation of labor." The general nature of the transfer is illustrated in Fig. 1.1 Skilled craftsmen are reduced, to some extent, to the status of semiskilled machine operators, or unskilled laborers. The particular group affected may oppose any such change vigorously. Pride of craftsmanship has been lost in many concerns as a result of an increasing division of labor and the mechanization of work. To the employee, this means a loss of certain psychic income, represented by the pleasure that is derived

Fig. 1.1. A Semiautomatic Milling Operation. (Courtesy, Kearney & Trecker Co.)

from creative work. To the employer, it means a loss of the employee's interest in his work. This interest is a factor in the latter's morale and his diligent application to his job. Personnel departments in modern manufacturing establishments have endeavored to restore a pride of craftsmanship, or its equivalent, for this reason.

Interchangeable Manufacturing

A good illustration of the transfer of skill and knowledge from the mechanic to the machine is found in interchangeable manufacturing. The idea was conceived by a French gunsmith. It was developed during the last decade of the eighteenth century by Eli Whitney, inventor of the cotton gin, and Simeon North, a Connecticut manufacturer. Interchangeable manufacturing has facilitated the further division of labor, reduced the cost of manufacturing assembled products and increased their serviceability to the public. A brief explanation of interchangeability is required because of its great effect on the development of industry.

We shall suppose that in the manufacture of a piece, shown in Fig. 1.2, it is necessary to drill a hole in the location indicated. If a single piece

were made by a skilled mechanic, it would be necessary first to machine accurately its outside surfaces. Then the piece would be placed on a surface plate, and lines would be scribed locating the position of the hole. The intersection of these lines would be prick-punched lightly. A drill of the right size would be set up in a drilling machine, and the hole would then be drilled in the location indicated. The work would require considerable skill and knowledge, and would be correspondingly expensive.

If we wished to manufacture these pieces interchangeably, in quantities, we would have a mechanic make a "drill jig." This is a movable device for holding work in proper relation to the tool of a machine. The pieces come

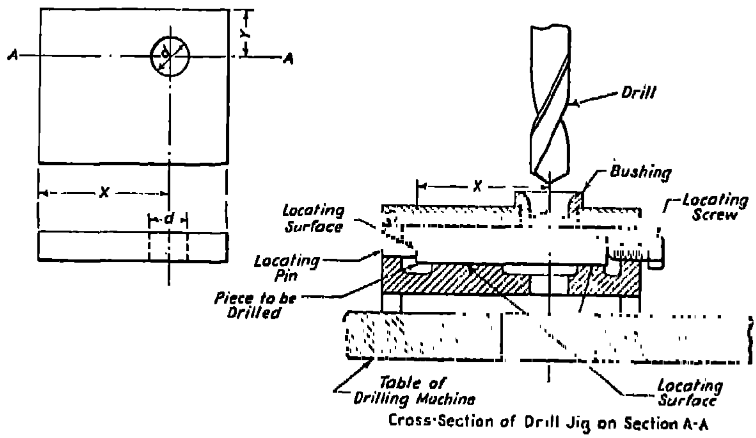


Fig. 1.2. Illustration of Interchangeability

to the drilling machine operator with their outside surfaces accurately machined. (In this stage, they are often referred to as "blanks.") In Fig. 1.2 the blank rests against certain pegs. These are "holding points." They have been accurately spaced and located so that the blank is held in the right relation to the bushing through which the drill is fed. If the jig has been made correctly, a drill of the right dimension must drill a hole in the location X-Y in each blank. Once the drilling machine has been set up, little skill and knowledge are required. The operator must merely be certain that the blanks are seated properly against the holding points. In other words, skill and knowledge have been transferred from the mechanic to the jig. Furthermore, each piece will be like each successive piece, within small limits of variation. If a plate has to be assembled with other parts, any one of the drilled plates will do. This would not be the case if handicraft methods were used. Each piece then would have to be fitted directly to the other pieces with which it worked in the mechanism.

If a piece were broken, it might be necessary to return the mechanism to the factory. This would hardly make for customer convenience. Today we expect to get a repair part from a local dealer or the factory without delay; and if the part does not work quite so well as the original one we feel that we are justified in complaining. We sometimes forget that the high degree of interchangeability, whose benefits we enjoy today, is a relatively recent thing.

The tools of production were simple and inexpensive during the handicraft stage of industry. A journeyman had an opportunity to become a master, and engage in business on his own account, if he could satisfy the requirements of his guild. This has become impossible in many fields of industry, because of the large amounts of capital required and the necessity for large-scale organization. Distinct groups of owners and investors, executives and operatives have developed. A great many people must necessarily work for wages or salaries throughout their lives. The result is various conflicts between the personal interests of employees and owners. These conflicts are a basic cause of many serious morale problems in modern industry. They are sometimes resolved by compromise between the contesting parties, with little regard for the public interest. Such conflicts have been a cause of the regulation of industry and labor.

Large-scale organization has a public advantage that more than offsets the difficulties noted above. The growth of large industries creates a need for small service industries. The proportion of small business does not appear to have changed significantly with the development of large organizations.

There is an effect of mechanization that offsets the so-called "degradation of labor." It has been called the "elevation of labor." In the heyday of craftsmanship, under the guild system of production, men were living under an agricultural economy. The craftsmen were outnumbered by serfs and villeins. The latter were bound to the land. They worked for a bare subsistence from sunup to sundown, under conditions that would not be permitted today. Many of these people progressed gradually from the status of unskilled laborers to that of semiskilled machine operators. This came with the breakdown of feudalism and the handicraft system, and the development of an industrial economy. They acquired greater real income and liberty. This tendency of mechanization to elevate the economic status of unskilled labor still persists.

The Development of American Industry

Our industrial history really begins with the close of the Revolutionary War. Samuel Slater brought over, in his head, the plans of the new English textile machinery. He established the first factory at Pawtucket, Rhode Island, in 1790. A great development of transportation and communication, accompanied by rapidly broadening markets, began with the nineteenth century. Canals were developed between 1817 and 1837. The railroad-building era began about 1830 and continued until the close of the century. The Seldon patents for the automobile were granted in 1895. The experiments of the Wright brothers with gliders at Kitty Hawk, North Carolina, in 1901, led shortly to the development of the airplane. The field of communications was broadened by the telegraph, invented by Samuel Morse in 1844, and the telephone, invented by Alexander Graham Bell in 1875. Marconi made the first successful demonstration of wireless telegraphy in 1896. This was followed about 10 years later by the invention of wireless telephony.

During this period of approximately 100 years, the last great physical frontiers of the United States were conquered. Business frontiers were being pushed back with them. Large amounts of new capital were needed for the rapid expansion of industry and commerce. Banking and financial systems were developing. The importance of financiers and capitalists increased greatly. As production and distribution became more complex, the manufacturer-wholesaler-retailer-consumer chain grew necessarily. Increasing aggregations of capital were necessary for the conduct of business over rapidly widening trade areas. Business organizations increased in size and in complexity of function.

These developments changed the environment and the problems of management. They were undoubtedly factors in the rapid growth of the corporate form of organization, particularly after 1890. They resulted in many economic advantages. They also caused many difficulties, such as abuses of economic power, absentee control of industry, and others.

It is a natural tendency to extend further the functions of the machine, to increase its capacity, and to apply power to it in greater quantities in order that it may do more work. The machine, in consequence, tends to become larger, more complicated, and more expensive to make. An ancient method of making a metal bowl was first to carve its form in a wooden block. A thin sheet of ductile metal then was hammered into the form, or die, thus making it take the desired shape. The method of drawing the sheet metal parts of automobile bodies is the lineal descendant of this

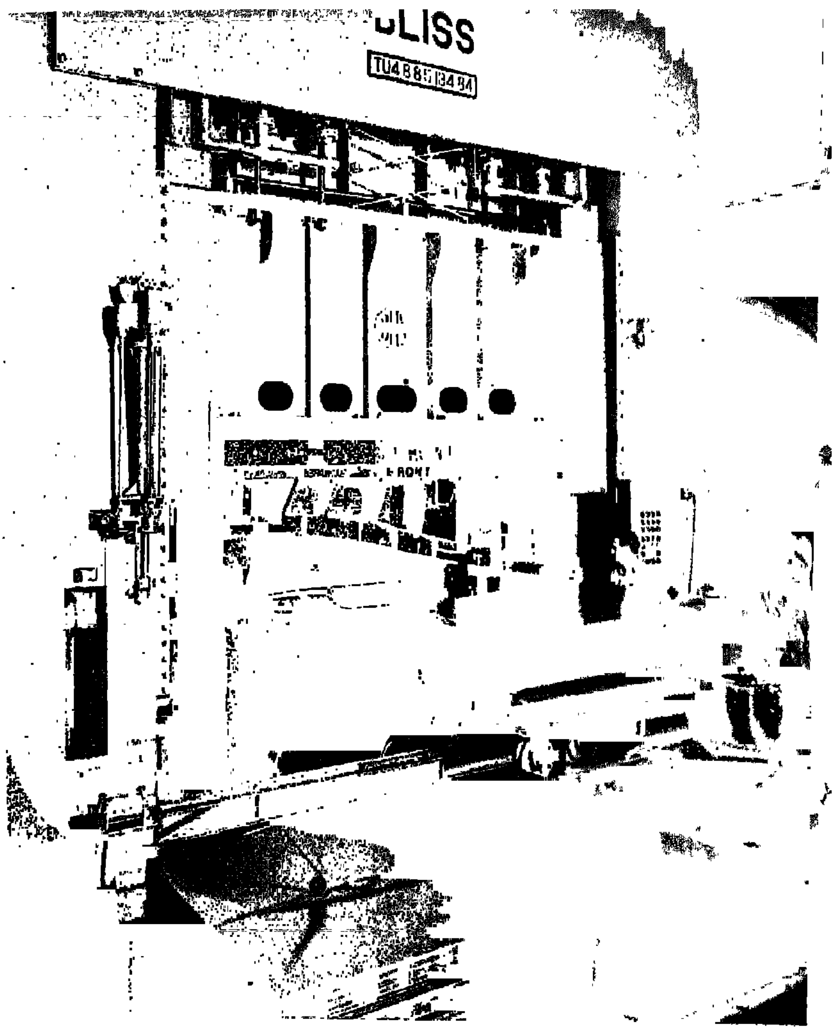


Fig. 1.3. A Press Used in Drawing Sheet Metal Parts. (Courtesy, E. W. Bliss Co.)

primitive process. The drawing presses shown in Fig. 1.3 would extend through two floors of the ordinary dwelling house. Large drawing presses may cost from $125,000 to $250,000 each, including the dies; a big automobile concern requires batteries of them.

Such developments have led necessarily to the aggregation of capital. The amount required to enter business in some industries is far more than any one person could supply. Hence large numbers of individuals must pool their capital, under a corporate form of organization, before the enterprise can be launched. A corporation's functions are extremely complex. Stockholders must necessarily delegate the right to manage to

a board of directors, and through them to the executives of the organization. The latter, being responsible for great amounts of capital and thousands of employees, must have wide discretionary powers, and therefore considerable authority. Thus we see that the aggregation of capital may lead to increasing concentration of economic power in the hands of executives. If this power is abused, competition may be affected adversely and serious social repercussions may develop. Nevertheless, the progress of industry depends largely on the exercise of initiative by all the executives in the organization, from the president to a supervisor. A modern problem is to regulate economic power without infringing on the right of executive leadership in any way that might hinder industrial progress.

Developments such as the above have resulted in the creation of many industrial relations problems. For example, the production and distribution of goods over greater and greater areas was a factor tending to produce clashes of interests between owner and employee. Under the handicraft industry that existed in the early days of the colonies, the quality and prices of goods and the hours and wages of labor frequently were fixed by law. Such regulations were satisfactory as long as production and distribution were largely local, the number and variety of goods offered to the public were relatively limited, and manufacturing and distributing processes were simple. These regulations tended to accentuate quality competition and to minimize price competition. However, as trade areas spread beyond local jurisdictions, these regulations tended to break down. Goods from different producing areas met in some neutral market, perhaps at a considerable distance from the point of production. As producers and distributors competed for a larger share of the market, attention was focused more and more on costs of production, with a view to offering goods at a lower price. Under handicraft or semihandicraft conditions, labor cost necessarily constituted a large part of the total cost of the product. There would be a tendency, in consequence, to reduce and hold wage rates to a minimum. It is apparent that widening markets tended to change the basis of competition from quality to price, and to create the concept of a fundamental clash of interests between those who own or manage and those who engage in operative performance.

Management has realized gradually that mass production requires mass distribution, which in turn requires mass purchasing power. Employees constitute a large part of the consuming public. When certain manufacturers attempt to reduce costs by reducing wage rates, other manufacturers may be forced by competition to do likewise; and if this goes far

enough, industry may reduce the consuming capacity of its markets, to its own detriment. Progressive manufacturers exhaust all other possibilities of reducing expenses during a depression before they reduce wages. They try to keep the reductions of wages within corresponding reductions in living costs, when it becomes necessary.

Problems in the Development of an Industrial Economy

The labor problem has developed concurrently with the growth of industry in the United States. Industry was in the handicraft stage of production in Colonial America. Work stoppages occurred occasionally. They represented, for the most part, joint protests by masters and journeymen against burdensome public regulations of prices, wages, and business conditions. A few labor organizations were formed between the close of the Revolutionary War and 1850. They were weak financially. They attempted usually to improve the conditions of the workman by political action. An example is a labor party that was formed in 1826, following a building trades strike in Philadelphia. It became split by internal political dissension. It disappeared in the depression of 1831. Various attempts to improve the conditions of the workman through socialistic forms of coöperation were made during this period. Robert Owen, a progressive British manufacturer, was the inspirational force in back of some well-known examples. He visited the United States in 1825, and again in 1840. The significance of such attempts rests chiefly in their universal failures.

Some of our present-day trade unions were formed following 1850. They were closely knit, militant organizations, created for the express purpose of advancing the economic interests of their members. The first national labor organization of importance was the Knights of Labor. It was organized in 1869 because of unsatisfactory conditions in the Philadelphia garment industry. It had approximately one million members at the peak of its power. It had practically disappeared by the end of the century.

The American Federation of Labor was organized by Samuel Gompers in 1881. Its policies were intended to avoid the mistakes of earlier labor organizations. Its policy of local autonomy, for example, was opposed to that of the highly centralized and autocratic controls of the Knights of Labor. The Federation has always been opposed to communism and other advanced forms of socialism. This policy was influenced by the earlier failures of labor movements based on socialistic doctrines of labor coöperation. The Federation has had also a nonpartisan political policy. It has backed those candidates in any party that it considered to be friendly to its purposes.

The rapid development of the West, following the Civil War, was accompanied by a corresponding expansion of our railroad system. There was a rapid growth of manufacturing enterprise and the corporate form of financial organization. There is always the danger that large uncontrolled powers in the hands of individuals will be used for their personal benefit and to the detriment of the public interest. The owners and managers of large enterprises, at the beginning of the present century, were no exception to this principle. Their abuses of economic power led to the passage of the Sherman Anti-Trust Act in 1893. Organized labor was specifically exempted from the operation of the antitrust laws, however, by the Clayton Act of 1913.

The Beginnings of a Management Science

A science may be any field of organized knowledge. The term implies a body of verifiable facts and principles that have been arranged systematically. The classification of this knowledge is intended to facilitate the solution of problems within the particular field. More research and study is required as these problems become more complex and difficult. The transition from an art to a science is usually gradual for this reason. The particular field never becomes completely scientific, however.

Management is the work of executive leadership. It is chiefly a mental activity. It has to do largely with planning, organizing, and controlling the work of others in the accomplishment of a group's objectives. Management is an applied science. It makes use, therefore, of the basic sciences, both exact and inexact. It depends somewhat more heavily on the latter, because of its leadership characteristics.

The mechanical and technological developments following the industrial revolution complicated and made more difficult the solution of economic problems. The business organization is an economic institution. It was inevitable that attempts would be made eventually to develop a science of management. This began shortly before the turn of the present century. There are two men whose names are associated intimately with the birth of scientific management: Henri Fayol of France and Frederick W. Taylor of the United States.

Fayol was born in 1841 of a middle-class French family. He was educated as a mining engineer. He became a mine manager at the age of 25. He was appointed managing director of Commentry-Fourchambault, a large French coal-mining concern, at the age of 47. He had written extensively in the field of coal-mining technology up to this time. His writings, following his elevation to the managing directorship, had to do chiefly with the field of administrative management. His monograph *Industrial*

and General Administration has had a great impact on American management thought, since its first English translation in 1929 by the International Management Institute of the League of Nations.[1] General administrative management frequently is called "administration" or "top management." Many of the general management principles in texts on these subjects were stated originally by Fayol.

Frederick W. Taylor is regarded as the founder of the scientific management movement in the United States. He was born at Germantown, Pennsylvania, in 1856. Like Fayol, he came from a middle-class family in comfortable circumstances. Its males members had usually been merchants or professional men. Taylor's original ambition was to engage in the practice of law. He graduated from Phillips Exeter Academy with honors in 1874. He entered Harvard University for the study of law, but was forced to withdraw because of failing eyesight.

Taylor became interested in industry. His next four years were spent in learning the machinist and patternmaker trades in a small shop on the outskirts of Philadelphia. He obtained a job as a yard laborer with the Midvale Steel Company in 1878, after completing his apprenticeship. The United States was still suffering from the depression of 1873. He progressed to shop clerk, machinist, gang boss, and to managerial positions in the organization. He left the company in 1890.

He served industry for several years as a management consultant. He published an article on his piece-rate system in 1895. It received widespread attention, and had considerable influence. The majority of businessmen seized the idea of piece work without realizing, unfortunately, that a sound, rational basis of management is necessary for this or any other management development.

Taylor was employed by the Bethlehem Steel Company in 1898. He made his study here of the handling of pig iron. It has been regarded as a classic example of job standardization and the application of the principle of wage payment in proportion to production. He and an associate, Maunsel White, conducted a series of investigations of the laws governing the cutting of metals. The resulting discovery of high-speed steel revolutionized the machine tool industry and metal-working methods. He left the Bethlehem Steel Company in 1901.

Taylor engaged subsequently in the installation of his methods in various plants, in research in management problems, and in popularizing his management philosophy. The public, for the most part, had failed to

[1] A more recent translation, entitled *General and Industrial Management*, by Constance Storrs, was published by the Pitman Publishing Corporation in 1949.

appreciate the principles of management in his piece-rate paper. He wrote his paper on *Shop Management* to correct this situation. It was his presidential address before the American Society of Mechanical Engineers in 1903. The results of his metal-cutting investigations were presented before the Society in 1906, in his paper entitled *The Art of Cutting Metals.* Louis Brandeis aroused great public interest in scientific management in 1910, during certain railroad rate hearings. Taylor's testimony before a special committee of the House of Representatives in 1912 also attracted widespread attention. His *Principles of Scientific Management* was published in 1912. He continued his work for the advancement of scientific management until his death in 1915.

Associated with Taylor were a number of men who later carried on and extended his work. Carl Barth and H. L. Gantt were possibly the most notable. Gantt, who died in 1922, was known for his *Work, Wages and Profits,* and other writings. Both men were active in the installation of modern management methods. There are many other men, such as James Mapes Dodge, Henry R. Town, Frank Gilbreth, Morris L. Cooke, H. K. Hathaway, Sanford E. Thompson, Dwight Merrick, and Wallace Clark, whose names will live in the literature of scientific management. Harrington Emerson requires separate recognition as a management pioneer. He was a contemporary of Taylor. He developed his principles and practices independently, nevertheless. He affected scientific management thought profoundly through his writings. These men have been followed by many contemporary students and practitioners of management, both academic and executive. They have the responsibility for a further development of a sound management philosophy.

It is evident, no doubt, that the philosophies of Fayol and Taylor were not competitive or mutually exclusive. They complemented one another. Fayol became interested in administrative management when he was faced with top management problems. Taylor became interested in operative management problems as he worked up from the bottom. These two fields of management shade into one another. There are basic management principles that are common to both.

Taylor's Philosophy of Management

Taylor was not a theorist; he was rather a keen observer, analyst, and student, with some scientific training. He appears, nevertheless, to have gained most of his ideas from practical experience. The foundations of his philosophy were laid while he was at Midvale. His interest in management and management problems developed directly from his experiences as an

operative employee. For example, his experiences resulted in his belief that neither the management nor the men really knew what constituted a fair day's work, and that this was the cause of much of the misunderstanding and strife between them. The later refinements and developments in his philosophy were likewise made under actual business conditions.

The meaning and significance of the term "scientific management" is not generally understood. Management has been defined as the function of planning, organizing, and controlling the activities of an organization in whole or in part. Its purpose is leadership of an organization in the achievement of its objectives. Taylor defined management as "knowing exactly what you want men to do, and then seeing that they do it in the best and cheapest way."[2] The scientific method is any method that applies the logic of reflective thinking to determined facts and principles in the solution of some problem. Such terms as the "legal method of attack," the "engineering method of attack," the "method of medical diagnosis," etc., refer to modifications of the scientific method to meet the needs of special fields. Scientific management is merely the application of the scientific method of attack to the solution of business problems. It may be simple or complex, depending on whether these problems are simple or complex. Management should be regarded as a distinct professional field in itself. As such, it draws on related or foundation fields such as engineering, economics, and psychology for whatever principles and procedures may be useful to it. Its independent character is evidenced by its spread into governmental and military fields.

Taylor's ultimate objectives in the development of a science of management were basically those that have been stated above. He developed certain fundamental principles. They may be summarized as follows:

1. Effective management requires the accurate measurement of the forces, factors, and effects in a business situation. Therefore an accurate body of facts relating to them should be developed, by experimental research when necessary.
2. From these facts, laws of managerial and operative performance should be derived, establishing the correct relationships between these factors, forces, and effects.
3. Standards should be developed in order that there may be criteria of proper conditions and relations in a given situation. They are necessary for the work of planning, organizing, and controlling activities. These standards must be maintained if they are to have continuing effectiveness.
4. Maximum economy and effectiveness require that these conditions and relationships be preplanned. Taylor's definite separation of the functions of

[2] Frederick W. Taylor, *Shop Management*, Harper & Brothers, 1911, p. 21.

managerial planning from operative performance is regarded as one of his great contributions.

5. Definite procedures, specifying the correct methods for managerial and operative performance, should be developed.[3]

Taylor's immediate objectives in the application of his principles were: (1) high wages, (2) low unit costs, and (3) improved and standardized working conditions.[4] High wages should be paid to the employee for the attainment of exact, accurate, and just standards of production. Taylor felt that an important cause of low wages and high costs in industry is the ignorance on the part of employers and their foremen—and also to a large extent, the employees themslves—as to the time required for various kinds of work. An example of this ignorance is the piece rate that is set by a foreman and then cut because employees are earning unusually high wages. It is an example that is not found today in well-managed plants. A fair standard of production should be determined. It should not be modified unless there is some distinct and material improvement in the method of performing the operation, or a change in the design of the product. High wages resulting from the employee's greater and more efficient application to his work, and the more efficient application of machines and materials, will result in low unit costs. Wages incentives will not lower quality when the best methods of processing have been determined, the employees have been instructed in these methods and their work is inspected.

Taylor developed a great many principles and policies for the guidance of management. He regarded the principles stated below as particularly pertinent to the achievement of his objectives. Taylor said:

The writer has already indicated that he thinks the first objective in management is to unite high wages with a low labor cost. He believes that this object can be most easily attained by the application of the following principles:

1. *A Large Daily Task.* Each man in the establishment, high or low, should daily have a clearly defined task laid out before him. This task . . . should be circumscribed carefully and completely, and should not be easy to accomplish.

2. *Standard Conditions.* . . . The workman should be given such standardized conditions and appliances as will enable him to accomplish his task with certainty.

[3] This summary differs from that of Dr. H. S. Person. See Taylor Society, *Scientific Management in American Industry*, edited by H. S. Person, Harper & Brothers, 1929, p. 4.

[4] Frederick W. Taylor, *op. cit.*, pp. 22, 123-124.

3. *High Pay for Success.* He should be sure of large pay when he accomplishes his task.
4. *Loss in Case of Failure.* When he fails he should be sure that sooner or later he will be the loser by it.[5]

There has never been a "Taylor system" in the sense of a set of forms, procedures, detailed rules, etc. While Taylor employed certain mechanisms, he adapted the applications of his principles to the conditions and requirements of each business situation as he found it.

World War I and the Great Depression

World War I had certain well-defined effects on labor and management. It accelerated the growth of the labor unions. It stimulated also the development of personnel management. Industrial organization and operation have become more complex. Personnel problems in large organizations now require the services of people with a specialized background, training, and experience. The personnel executive usually has an important place in a business organization today.

A world-wide depression of unprecedented severity began in 1929. Prices of labor and commodities fell rapidly. Chaotic conditions developed. Loss of confidence in business leaders also developed. It is questionable whether, as a whole, they merited the extreme condemnation that they received. They were confronted by tremendous forces that were beyond the power of national governments to control. On the other hand, too many cases of poor business ethics were disclosed. They received wide publicity in the press. Various theories concerning the causes of the depression were advanced. It was felt in many quarters that these malpractices were a partial cause. Many people attributed the depression to an inequitable distribution of the national income, to a failure to maintain mass purchasing power. They believed that a more highly centralized control of economic activity vested in the federal government could prevent or minimize recurrent depression, produce what they regarded as a more equitable distribution of income, bring about general economic security, and in other ways create the "good life." We are concerned here not with the validity of these arguments. We are concerned with public attitudes as they affect the work of management.

As a step toward a planned economy, the National Industrial Recovery Act was passed in June, 1933. The Act guaranteed to labor the right of collective bargaining. It provided for codes for our principal industries. These codes contained restatements of the collective bargaining clause, as

[5] *Ibid.*, pp. 63-64.

well as various fair-practice provisions covering business and labor relations. Many people felt that the codes tended to foster price fixing, to promote a monopoly, to inject serious rigidities in our economic system, to limit economic opportunity, etc. On the other hand, many employers considered the basic idea fundamentally sound, because such codes tended to place a premium on superior managerial ability by making it difficult to achieve business success through sharp practices. Organized labor favored it for the most part. The act was declared unconstitutional.

In May, 1935, the National Labor Relations Act was introduced in Congress, subsequently passed, and eventually declared constitutional by the Supreme Court. In so doing, the Court held that strikes may interrupt the flow of interstate commerce, and are therefore a proper subject of legislation by Congress. In consequence, the labor relations of any sizable concern have become charged with a public interest. Many employers believed that the Labor Relations Act was unfair. They felt that it interfered with management's legitimate exercise of executive leadership; that it placed great obligations and restrictions on management without imposing corresponding obligations and restrictions on organized labor.

In November, 1935, a group of important national labor unions separated themselves from the American Federation of Labor and formed the Committee for Industrial Organization[6] under the leadership of John L. Lewis. They believed that the craft-union form of labor organization favored by the A.F. of L. is ineffective in the case of unskilled and semiskilled employees, particularly in the mass-production industries. When a policy of vertical labor organization was not approved by the Federation convention in 1935, these men withdrew and formed the C.I.O. They initiated subsequently a vigorous organizing campaign. It resulted in the formation of strong unions in the steel, automobile, rubber, and other large industries in which there had been few unions previously. The C.I.O. was criticized severely by employers for its militant organizing activities. Some industrial leaders alleged that some C.I.O. leaders were communists; that the C.I.O. condoned the "sit-down" strikes and other forms of labor violence; that it intimidated employees and coerced them into joining its unions; and that it engaged in other practices not in the public interest.

These and other developments began with the "New Deal" in 1932. They accelerated the growth of "Big Government," as well as "Big

[6] The original temporary form of organization was changed to a more permanent form, and the title has been changed to the Congress of Industrial Organizations.

Labor." These developments modified greatly the basic concepts of private property, free markets, and free enterprise under which American executives perform their managerial functions.

World War II and the Postwar Economy

Industry operated under a highly controlled economy during World War II. The pressure for production was great following the Japanese attack on Pearl Harbor on December 7, 1941. We were poorly prepared for the subsequent conflict. Quantity and quality consequently were first considerations in war production. It was necessary frequently to sacrifice expense to time. The War Production Board controlled materials and equipment. The War Labor Board controlled the labor supply. The Reconstruction Finance Corporation, through subsidiaries such as the Defense Plant Corporation, facilitated the expansion of the nation's manufacturing capacity. Civilian goods were rationed. Prices were controlled. Many manufacturers had only one customer—the government. Defense contract prices were subject to renegotiation. Considerations of national security required the operation temporarily of such a highly controlled economy. It reduced free competition and free markets to a minimum, nevertheless. Conditions were not conducive to efficient, prudent management.

World War II ended with the defeat of Germany and Japan in 1945. The postwar period was one of unrest and unsettlement. The fruits of victory were lost to a great degree. Soviet Russia became a greater threat to liberty and democracy than our World War II adversaries. England elected a socialist labor government. Communist infiltration into governmental agencies in this country was proved. The C.I.O. purged itself of some important unions which were alleged to be dominated by communists. The C.I.O., and to a lesser degree the A.F. of L., were successful in advancing their economic interests through political action. They were able to develop strong monopolies of the right to work in some economic fields in some parts of the country. Executives complained that they were compelled, by resulting economic pressure on the general public, and the intervention of governmental agencies, to grant uneconomic privileges and pay raises to employees. These executives, on the other hand, were accused of complaining less loudly when they were able to pass the increased costs to the public in the price of the product. The National Labor Relations Act of 1935, known as the Wagner Act, was amended in 1948 to become the Labor Management Relations Act. This is the Taft-Hartley Act. It reaffirmed the rights of employees and unions as specified

originally in the Wagner Act. It specified in addition certain unfair labor practices. It stated also certain employer rights in the field of labor relations. The A.F. of L. and the C.I.O. merged in 1955 to gain greater political and economic strength.

A policy of "controlled inflation" operated during this period. The prices of goods and services rose steadily. Large quantities of goods were shipped to foreign countries to foster the economic recovery of these countries and stop the spread of communism. The domestic demand was inflated also. There was a great expansion of manufacturing capacity. Millions of dollars were spent for product and process research. These tendencies were accelerated by the beginning of the Korean "police action" in 1949. Machine tools had been improved during World War II because of the pressure for production. The improvement was continued because of increasing labor costs. Some of the wartime materials, labor, and price controls were reintroduced. There was some talk of a "garrison state" because of World political tensions. It was feared that they would necessitate substantial governmental control of industry for an indefinite period. A dispute arose between the C.I.O. Steelworker's Union and the steel industry in 1951. It was referred by the President to the U.S. Wage Stabilization Board. A rejection of the Board's recommendations by the industry's management resulted in a temporary seizure of the industry by order of the President. The action resulted immediately in court action and widespread controversy. Questions were raised concerning the relation of this action to a continuous breakdown of the right of private property.

There was a change of national political administration in 1952: This administration was continued by the national elections of 1956. It has followed a "middle-of-the-road" policy in dealing with business and labor. Events since 1952 are still too recent to permit evaluation. It is obvious that they have had significant influence on management thinking and policy; how much is a problem for future business historians.

Management must be interested in broad problems today. The right of private property is necessary for the operation of a system of free enterprise and free markets, as well as the preservation of individual liberty and democratic government. Managerial effectiveness depends on the maintenance of such institutions. The interest of executives in the philosophy of management has grown rapidly during this period, and probably for this reason. The development of this interest is most significant. Executives have recognized, certainly, that they need public support in the solution of economic problems. More executives realize

that this support depends on the development of an acceptable management doctrine. Executives in some communities have made a concerted effort to gain public understanding and acceptance of their point of view. Much thought has been given to the problem of organizational morale. They have reëxamined their thinking in an effort to regain much support that has been lost. They have attempted to develop better leadership at every executive level, including supervisory management. Organization structure as an instrument of coöperation and leadership has been studied. Other interesting developments have taken place. The result should be a more effective job of planning, organizing, and controlling the work of the business organization. This work is primarily the highly important task of supplying the public with more goods of better quality at lower costs. It is fundamental to a continuing improvement of our high standard of living.

CHAPTER 2

Basic Management Problems

The Importance of Fundamentals

EXECUTIVE interest in the development of a philosophy of management has increased greatly since the close of World War II. This has been due primarily to political and social pressures on management. They have caused executives to reëxamine the bases of their leadership positions in business organizations. It has been recognized increasingly that management is the function of executive leadership. The need for a critical examination of the bases of sound management has become obvious.

A philosophy is merely a system of thought concerning certain phenomena in a particular field of knowledge, and the problems that are related to them. It relates certain general objectives, principles, functions, factors, points of view, and methods of attack, in a manner that facilitates problem-solving thought. A sound philosophy is the basis of effective thinking, and therefore of successful action. For this reason, it is usually the most practical consideration in any field of activity. A philosophy of management is a system of thought concerning certain fundamental business problems. It serves as a basis for their solution.

Most business problems are concerned primarily with the organization of the business, or its operation. It is impossible to consider organizational problems without considering relevant operating problems at the same time. The converse of this is equally true. Knowledge of the general principles of organization and operation is therefore fundamental to the solution of any business problem. The applicability of these principles tends to be universal.

It is contrary to the observed facts to assume that there is a body of these basic principles that is peculiar to the field of finance, another that is peculiar to distribution, and still a third that is peculiar to manufacturing. Many general executives during World War II took over top leadership positions successfully in new concerns manufacturing products that

had never been made before. Some general officers in the Armed Services have successfully taken over top executive jobs in business organizations since the war. One hears occasionally of top executives who transfer successfully from one major business field to another. It is apparent that extensive practical experience cannot explain entirely the success of such men in their new fields of activity.

The universality of fundamental business principles also furnishes a partial explanation of the failure of many mature business executives. Such men often have a wealth of "practical" experience. They are familiar with the details of the various problems in their particular field. They understand the specific factors that usually affect their problems, and their force and effect. They know the methods for handling these factors that have proved successful in the past. As long as there is little change in the business situation, and such change is gradual, these men may be quite successful. A sudden radical change is usually accompanied by high executive mortality. Such a change may result from an unusually severe depression. It may be caused by new and extensive social demands on business. Rapid and radical alterations in the company's product or service, and other causes may accelerate changes. They may make obsolete much of the empirical knowledge that the executive has built up through long experience. He must fall back on the more fundamental and universal principles underlying all organization and operation. Otherwise, he may not be successful in devising new structures and procedures to meet these new situations. Many executive failures during World War II were due to continuous and rapid change. Business factors and functions change necessarily with a changing business environment. The fundamental principles and general methods of attack change slowly, if at all. If the executive has an understanding of these principles and methods, plus the necessary experience and intelligence, he may be successful in meeting his new problems. He may be forced to step aside, if he has merely experience and intelligence. A continuing enjoyment of the right of leadership, with its greater rewards, must rest on continuing ability to lead. Any concept of tenure of office based on previous success and length of service loses its validity increasingly as one acquires greater leadership responsibilites. No executive has a right to bottleneck his own organization.

A significant continuous violation of any fundamental business principle must be followed by serious and far-reaching results. If an executive fails to handle properly some specific factor in a given problem, the result may be a serious short-term loss. Its effects usually are localized. A violation

of some fundamental principle of organization or operation may cause losses that are far greater. The results may not be immediate, but they may affect, ultimately, the whole business. Their effects may continue until some fundamental corrective action which is often quite expensive, is applied.

This being the case, it is hard to understand why basic difficulties in an organization are sometimes allowed to continue for a considerable time. The causes may be many. They may include the management's apathetic attitude toward improvement. They may be the result of continuing but mediocre profits. They may be effects of opposition to any change because of mental inertia or personal ambitions. They may reflect inability to recognize the necessity for change because of the lack of an adequate understanding of the basic fundamentals of organization and operation. They may be due to the intangible nature of organizational problems, which seems to place them beyond the mental capacity of some executives.

Basic Factors in Organization and Operation

A business function is any distinct phase of the work of a business organization. A business factor may be anything that affects the performance of this work. Successful solutions of business problems require the relation of business functions and factors to business objectives by means of sound business principles. There are certain basic business factors and problems, that are found in every field of business activity. An understanding of them is a requisite for an understanding of management. They are the following: organized society, business objectives, standards of business conduct, executive leadership, business policy, business functions, physical factors, personnel, organization structure, business procedure, and organization morale. The general relations between them are shown in Fig. 2.1.

Socialism is basically a system of economic centralism: the state owns or controls the means of production. Private enterprise is basically a system of economic decentralism: it rests on the right of private property. All rights reside ultimately in the individual under our political and economic system. The Constitution of the United States safeguards the right of the individual citizen to "life, liberty, and the pursuit of happiness." This includes and depends on his right to own and be secure in his property. The dominant religions in this country, furthermore, consider that the individual has been created in the image of God. All temporal rights reside inherently in the individual for this reason also. The citizen in a democracy, however, has the right to elect his representatives and

to delegate to them such of his rights as he sees fit. This may include the authority to modify and restrict generally the exercise of the right of private property by individuals within specified limits. This right of private property is merely the right of individuals to hold and use

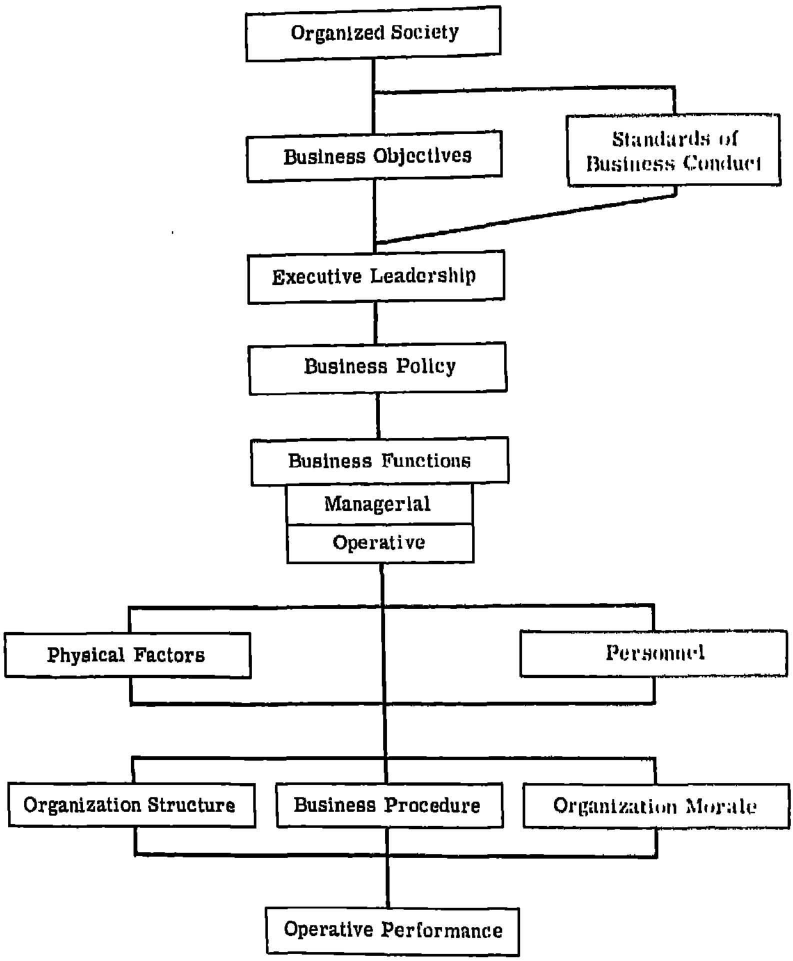


Fig. 2.1. Basic Management Factors and Problems

property for the benefit of their personal interests but with due regard for the public interest. It is the right that enables individuals to dispose or otherwise use their goods or services in whatever way appears to be most advantageous. It is the right that enables the workman to sell his services individually, or collectively through some labor organization, as

he chooses. It is the right that enables the owner of capital to decide how it shall be employed in business to accomplish whatever objectives are desirable and proper; to decide what work is necessary and who shall do it; to delegate to the designated executives and operatives the required responsibility and authority. It enables the stockholders of a corporation to delegate to a board of directors authority for the general conduct of the business. The board, in turn, is able to delegate authority to a president, and so on down through the organization. The authority exercised by a shop foreman or a department store buyer has its genesis in the owner's rights of private property. So does the operative authority of any workman. The authority of any employee, whether executive or operative, is distinct from his right to sell his services for an agreed compensation.

Organized society is the immediate source of all sanctions for the operation of all businesses, whether public or private, as shown above. The continued exercise of any right rests on a satisfactory and continuous discharge of certain corresponding obligations. Private enterprise is expected to contribute continuously to an increasing standard of living, under whatever conditions are prescribed by public policy. It is the obligation that corresponds to the right of private property on which private capitalism and free enterprise rest. This obligation requires the maintenance of free markets and free competition. Competitive private capitalism has reached its highest development in the United States. It exists because the American public believes that it can enjoy more goods of better quality at lower prices, together with better service, under a system of free enterprise. It requires merely a gradual modification of the right of private property, by constitutional methods, to change our system to one of public enterprise, state capitalism, and socialism. The proper discharge of managerial obligations by the executive leadership of business and industry is a fundamental factor in the continuance of our economic system, with its high standard of living.

It is significant that many top-flight executives are giving serious thought to such questions. It does not follow that they are becoming more theoretical than practical. Public attitudes influence policy decisions concerning what are sound business objectives. These attitudes govern what is required to maintain good public relations. They result occasionally in legislation that changes management conditions and methods adversely. Community attitudes affect the problem of developing good organizational morale. They influence business operations in other important ways.

Business Objectives

A value may be any satisfaction of a need or desire. The latter develops from some fundamental urge that an individual or group wishes to satisfy. It may have to do with the gregarious, play, sex, creative, or other urge. An objective is a value for which someone is willing to make the necessary effort or sacrifice to get it. It is not necessarily a material or tangible value. It may be some intangible satisfaction such as a feeling of worth-whileness growing out of association with a successful organization. The fundamental basis of value, then, is mental.

The business organization is an economic institution primarily. It is expected to acquire, create, preserve, or distribute certain economic values. These may be any satisfactions for which an individual or group is willing to exchange other values. The people involved may be a part of the organization, such as owners, executives, and operatives. They may be merely associated with the organization in the transaction. This would be the case with customers, suppliers, and bankers. The values exchanged must be proper, in any event. The methods employed must be in consonance with public policy.

The business objective is the point from which our business thinking starts. A brief classification and analysis of objectives is necessary, accordingly, for an understanding of managerial problems:

Classification of Business Objectives

1. *Primary Service Objectives*
   a. Organizational objectives
   b. Operational objectives
2. *Collateral Service Objectives*
   a. Personal objectives
   b. Social objectives
3. *Secondary Objectives*
   a. Effectiveness
   b. Economy

Primary Service Objectives

The primary objectives of the business organization are customer values. The primary mission of the organization is to serve the customer. Ours is a highly developed industrial society. The material values that sustain it are, for the most part, all the economic values distributed to all the customers of all business institutions everywhere. The justification of private enterprise is found in its superior ability to increase *per capita* production

continuously. This is the basis of a continuous increase in our standard of living.

Each company within an industry has, in addition, an immediate and practical reason for regarding customer values as the primary business objectives. The costs of doing business come out of the customer's dollar. Our ability to stay in business depends on our ability to get a sufficient number of these dollars. We may borrow from the banks temporarily. We may use other means of deficit financing. We shall be out of business eventually unless income from sales exceeds business expenses by a satisfactory margin over a period of time. We shall become less and less able to meet our payrolls, pay our suppliers, and plow profits back into the business for modernization and expansion. We shall find it difficult financially to take other measures to maintain our competitive position. Dividends, in any event, are likely to be few and far between when a company is operating at a loss.

We maintain in some reasonable degree free markets and free competition in the United States. The customer has freedom of choice of whatever goods and services are offered. There is no compulsion that requires anyone to buy a particular product. He buys it, if he does, because he feels that the product will satisfy some need at a price that he is willing to pay. A man does not buy a bundle of cloth, held together by some thread, when he buys a suit of clothes. He does not buy just physical protection from the elements either. He buys in addition certain intangible satisfactions, such as a feeling that his social status is improved by a distinctive garment. He may want that feeling of confidence that goes with a well-dressed appearance. There may be other intangible values that are associated with the garment. No doubt he will balance such values, both tangible and intangible, against the number of dollars that the merchant wants for the suit. It is the customer's privilege to walk out of the store if he decides against the purchase. There will be few orders for the garment manufacturer, if enough customers walk out of enough stores, or never enter them in the first place. His employees will have little work. He will probably suffer serious financial loss.

It is his privilege, of course, to take his loss and withdraw from business. A better answer is to find out what the customer wants and what it takes to give it to him at a profit. It is more practical, if one has the requisite managerial ability. Manufacturers spend, for this reason, many millions of dollars annually on marketing and industrial research. They need the answers to such questions as: What does the customer want? What must the product do and why? How much of it will the customer want and

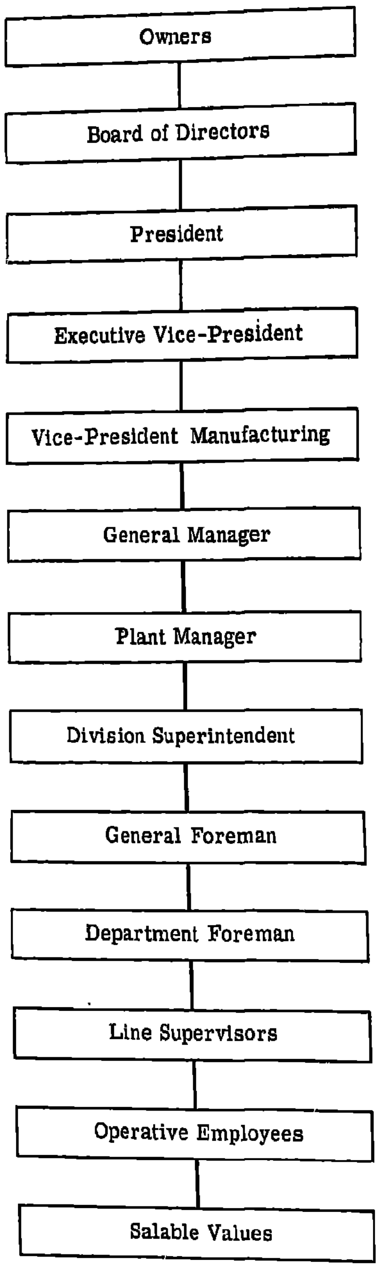


Fig. 2.2. A Primary Chain of Command

when? The answers to these and other questions underlie some important managerial decisions. They concern marketing problems, product design, equipment programs, financing, and others. Such research information aids us in answering a basic question: What is the organization's primary objective? The general answer is obvious: It is customer service in terms of the quality, quantity, time, and expense of whatever goods must be provided. The specific answer for particular products may be difficult to determine.

Primary service objectives fall into two broad categories, organizational and operational. Primary organizational objectives are primary values that must be contributed by each individual or group to the larger group in a primary chain of command of which it is a part. An illustration of such a chain is given in Fig. 2.2. It is represented by the president of the company, executive vice-president, the vice-president in charge of manufacturing, the general manager, a plant manager, a superintendent, a foreman, and a workman. The latter may be completing a step in the manufacture of a part of the product. This part is assembled with other parts to make a finished product. Various products are shipped to various customers. This goes on throughout the week, the month, and the year. We probably

have set up in advance of each time period a sales program, production program, and expense budgets by departments and divisions of the organization. They are based on estimates of the amounts of various products that we should be able to make and sell. The quality of these products is guarded carefully by specifications and inspections of completed work. These programs and budgets become goals toward which the organization as a whole is working. They are broken down, furthermore, into corresponding objectives for each division and department of the business. Each individual within each organization should have his service objectives. He should be held accountable for their accomplishment over the time period, provided that they have been set fairly and accurately. His service objectives are measures of his contribution, and therefore of his performance. It is evident that we have individual, minor, and major service objectives, as well as general organizational objectives. They are set up definitely and specifically in terms of quantity, quality, time, and expense. They play an important role in planning and controlling company activities. We shall service presumably our customers as well or better than our competitors if each individual and group within the organization accomplishes its primary service objectives. We do much more, obviously, than just talk about customer service.

The employee in the preceding paragraph was working on an operation on a part of one of our products. That part must perform some mechanical functions in the finished product, as specified by our engineers. We may have a dissatisfied customer if it does not. Each step or operation therefore should have certain performance standards. These are intended to assure customer satisfaction with the product. These standards are criteria of required values, in terms of quantity, quality, time, and cost. It is evident that we must have objectives for each step in the completion of the project. They are intermediate objectives. The end values created by the project are its final objectives. An accomplishment of organizational objectives is obviously an accumulation of these end values for all projects that have been completed by the organization.

Collateral Objectives

Collateral objectives are those values that the business organization supplies to individuals or groups other than customers. The latter may be a part of the organization, such as owners and employees. They may be associated with the organization, but not a part of it, such as suppliers, bankers, or governmental agencies. Collateral objectives are values that must be supplied to secure the continued coöperation and support of such

groups. They must be distinguished from values supplied to organizational groups for the accomplishment of their service objectives. They are not customer values, obviously. They come eventually from the customer's dollar, nevertheless. The values furnished by the business organization to noncustomer groups must be regarded, then, as necessary but collateral objectives.

Such objectives fall into two categories, personal and social. Personal objectives are those values that individuals and groups want for themselves. The groups that are associated with the organization in the accomplishment of its mission include bankers, vendors, transportation agencies, consultants, and many others. The organization could not operate without their services. They have claims that must and should be paid. The groups within the organization also break down into two categories, owners and employees. The latter consists of executives and operatives. They have previously sold their services for an agreed compensation under the terms and conditions of some contract of employment, whether express or implied. They are members of the organization for the duration of their employment. They expect usually more than good money, hours, and working conditions, however. They may want certain privileges, services, and intangible values. A reasonable provision of whatever values they want is necessary to retain their interest, support, and coöperation. It is not easy, frequently, to determine what is reasonable. This will become evident when we look at the job of the personnel executive. A contract involves an exchange of values, of course. An organization member has an obligation to give reasonable support to executive leadership in the accomplishment of primary objectives, when a mutually satisfactory employment contract has been accomplished. This is not always recognized either.

The owners of the business have their personal objectives also. It makes little difference basically whether they are individuals, partners, or stockholders; whether they are big businessmen or little businessmen. They hope to make a profit. That is the reason, usually, why they risked their money in the first place. A profit has been defined as the reward of capital for the successful acceptance of business risk in the rendering of an economic service. The service must be rendered first, of course. Our economic philosophy requires that it shall be rendered under conditions of reasonable and fair competition. The costs of materials, labor, and other expenses must be deducted first. What is left is a profit or a loss. A profitable employment of capital, over a period of time, is necessary for the growth and expansion of industry. Capital includes more than money. It includes

plant, equipment, inventories, and other facilities. We shall look at some of them shortly. Our ability to increase our *per capita* production depends largely on capital and good management. A system of private capitalism cannot be operated without private capital. It must come largely from two sources: profits that have been plowed back into the business, or the savings of individuals. It is unlikely that savings will be invested voluntarily unless there is reasonable hope for a good return. The justification of a company's profit depends primarily on the economy and effectiveness with which it serves its customers under conditions of free, fair competition. The necessity for a profit depends primarily on the obligation of private enterprise to contribute continuously to an increasing standard of living. A profit is a collateral business objective and a personal objective of owners, regardless of its necessity and justification. It comes out of the customer's dollar.

The collateral social objectives of the business are difficult to define. They may include any broad general economic values that are deemed necessary to the well-being of society, provided that they are affected directly and materially by business activity. The business organization is not a social service agency. It is an economic institution. Yet it acts as an agent of the government in the collection of social security taxes from its employees. Most executives do not object seriously to this burden. They will object, of course, if the bases of competition are altered greatly. They expect, rightly, that the costs of such collateral service will be passed to the public in the price of the product. They will oppose usually any programs of such magnitude that consumer purchasing power may be reduced through consequent inflation. Progressive industrial leaders recognize, however, that the business organization has a public obligation in a modern industrial economy. It grows out of its vital relation to the public interest.

Secondary Service Objectives

Goods and services do not produce themselves, obviously. They are produced. This may take quite a bit of doing. It is necessary for some marketing executive to find out what it is that the customer wants, why, and other marketing information. Someone must determine what this means in terms of a salable product. Someone else must decide what is the best way to make this product. People must know what they are expected to do. They must know with whom they are expected to cooperate. So someone must make organizational plans, if we wish to get results. We should buy materials at the lowest price that is consistent with

satisfactory quality and other purchase requirements. We must coordinate the activities of hundreds of men and machines, in order that we may have an effective, economical utilization of them. All this, and much more is necessary. The reason is basic: the mission of industry to give its customers more for less, at a cost that will leave a reasonable profit. It must provide reasonably, at the same time, for the legitimate interests of those groups of people who are a part of or are associated with the organization. This means that it must provide customer values economically and effectively. What is economical and effective is determined by customer choice and competition. The customer does not buy economy and effectiveness, however. He buys what he considers to be satisfactory goods or services at a satisfactory price. The customer is under no obligation to pay a price that will underwrite losses due to poor management. Secondary objectives are values that the organization needs, to enable it to do this kind of a job. They are secondary, therefore, to customer values. They are very important nevertheless.

An understanding of secondary objectives also is necessary for an understanding of management. They are usually the principal objectives of staff organizations. Staff objectives condition the relations between staff and those line groups which produce primary values.

Standards of Business Conduct

Confidence is an important business value for many reasons. A customer tends to buy the same product from the same distributor, when he is confident that the product will always give satisfaction and the price will be reasonable. Repeat business is an important factor in the success of many business concerns. An executive tends to get the support and loyalty of his associates and subordinates when they have confidence in his fairness as well as in his ability. Satisfactory financing depends greatly on the confidence of our bankers in our integrity, as well as our ability. Public support in legislative or other problems depends on public confidence in the purposes of the company or the industry, relative to the public interest.

There are various groups which are associated with or are a part of the business organization. They include suppliers, dealers, bankers, employees, and investors. Our ability to gain their confidence and support depends on their belief in the rightness of our business ideals and standards of business conduct. Business ideals may be defined as moral values that are acquired through ethical conduct of business activity. They are related to but different from the collateral social objectives of the organization.

Standards of business conduct are the ethical criteria by which the propriety of business activities may be judged. No one is likely to have great confidence in a person or an organization whose ideas of proper action are considered to be unethical and unfair. The problem of business conduct, then, falls in the field of business ethics. It has to do with considerations of right and wrong in the conduct of business activities.

Our ideas of right and wrong are determined largely by custom and environment. They are associated with whatever moral values may be desired. They are derived ultimately from the dominant religious doctrines of the particular society. These values are essentially intangibles. Our criteria of proper business conduct are inexact accordingly. Our judgments concerning right and wrong business conduct are necessarily qualitative. The best that we can do usually is to express them in the form of codes of business conduct for the business or the industry. These codes are merely statements of principles and rules of action that we propose to follow. They put the organization on record, however. Conformity with them is not entirely a matter of good faith. It is a difficult matter to translate ethical principles into business policies and practices. It may be difficult to enforce compliance with them by the individuals within the organization. We may be forced to meet unethical competition from other organizations. Other problems in business ethics may present themselves.

The practical importance of business ethics is indicated by the large sums of money that are spent annually by many organizations to promote good business relations. This includes public relations, labor relations, customer relations, supplier relations, and in fact any relations that affect business activities. The writer recalls one organization that had solved its ethical problems in a very simple manner. It had just one rule: if it is legal, it is ethical. Most executives would agree that this is an inadequate and dangerous oversimplification. Such a legalistic attitude is not likely to result in good employee morale or the support of groups that are associated with the organization. Sound business relations are a personal responsibility of top management. Sound standards of business conduct will not be a factor in policy formulation, unless top management is interested in the problem of business ethics. Top executives must delegate much of their responsibility, however. The organization's reputation for business integrity therefore depends on every member in it. Policy enforcement can produce some minimum of results. No policy statement can be highly effective, unless organization members will conform to it voluntarily.

Executive Leadership

Business objectives and standards of business conduct are determined ultimately by forces and factors that are outside of the business organization. The public decides finally, through its elected representatives, what constitutes the public interest in our economic system. The customer decides, under a free economy, what he wants, how he wants it, when he will take delivery, how much he wants, what he is willing to pay for it, and similar questions affecting his economic interests. Other outside interests are free also to make decisions that affect the organization and its operations.

We are all working for the ultimate consumer in the end, whether we are making producers' or consumers' goods. The consumer is under no obligation to tell us what he wants and why. We try to find out, of course, through marketing research and other means. The initial decisions concerning what can be produced and sold must be made by owners and their executive employees. The company is successful if most decisions are correct. It may be unsuccessful if too many customers veto too many decisions in the market place. Executives make many other related decisions. These decisions may have to do with financing, engineering, personnel, procurement, and other problems. The executive group is relatively small in every business organization. Its importance is far greater than its numbers, for reasons indicated. The salaries paid to executives of all grades reflect this importance. An able executive in a key position must be replaced promptly, or other dispositions must be made, when his services are lost. Otherwise the business may suffer greatly. There are many reasons why executive leadership is a basic factor in business success, and one of the most important.

An organization basically is a group of individuals who are coöperating to a common end under the guidance of a leader. A particular organization may be good, bad, or indifferent from the standpoint of objectives, policies, or any other criterion. Most people consider a good organization to be one that is composed of capable people, who have been properly trained and implemented. This organization must accomplish its objectives economically, effectively, and ethically. This requires competent leaders. It requires good organizational morale also. A leader may be anyone who accepts responsibility, when it has been delegated to him properly, for the accomplishment of group objectives. He must be able to discharge his responsibilities in a manner that will gain the support of his group. Otherwise the morale of his organization and its effectiveness will

drop. An executive is broadly anyone who is charged with the management of affairs. He is responsible, in some degree, for planning, organizing, and controlling the work of the particular organization that he leads. A business executive may be anyone who leads a business organization, or some element of it.

The term executive, therefore, includes any employee who has personal responsibility for directing and supervising the work of others. The leadership responsibility of an executive must constitute his principal assignment. The term, accordingly, includes everyone from the chairman of the board to a supervisor within a department. The question is not whether they are on the same "management team." The question is, rather: How well are they playing their leadership positions? This is determined, ultimately, by how well they are accomplishing the service objectives of their organizations.

The primary contribution of the executive, then, is leadership. The work of leadership anywhere is management. It is the work of planning, organizing, and controlling the work of others for the accomplishment of the organization's primary objectives. It requires a satisfactory accomplishment of secondary objectives, with due regard for the personal objectives of organization members. The principles of effective leadership are the principles of good management. We shall discuss them further when we examine the work of the various departments and divisions that make up the industrial organization.

Some readers of management texts look for the golden formula for executive success. There is none. An examination of a list of executive traits can only clarify some of the requirements for executive leadership. There are many lists of this kind. The following list has been helpful to the writer: intelligence, experience, originality, receptiveness, personality, teaching ability, initiative, tenacity, courage, human understanding, and a sense of justice and fair play. Management is largely mental work. An executive must plan, organize, and control the work of his organization, or see that it is done properly by subordinates. This requires a degree of intelligence and experience that is above average. The term "experience," as used here, includes both knowledge and know-how. Originality and receptiveness are necessary because of the requirements of a competitive economy. We cannot continue to do the same old things in the same old way. Our society demands increasing *per capita* productivity to support an increasing standard of living for everyone. The executive must be receptive to new ideas of his subordinates or any one else. It is his responsibility, of course, to determine whether the ideas are sound and prac-

ticable in his business. It will be agreed, nevertheless that "cast-iron" thinking is not compatible with effective competition. Personality is usually an important factor in leadership success. A good personality is helpful in gaining the liking, confidence, coöperation, and support of one's associates and subordinates. It is a personality that tends to evoke a favorable reaction from people with whom the executive comes in contact. It should be one that wears well. It is the result of some combination of mental and physical attributes in the individual. It is difficult to analyze, define, and measure. An effective combination differs for different people under different circumstances. A staff job, for example, in which one exercises a leadership of ideas, may require a different personality than a line job in which one exercises a leadership of action. Yet two men with different personalities may operate successfully in like jobs. Both personalities may evoke favorable reactions. Sometimes a personality deficiency may be overcome by other factors in executive success. Teaching ability is important because the problem involves more than getting oneself across to one's associates and subordinates. One must get across one's ideas also. This assumes the ability to produce good ideas, which takes us back to the necessity for intelligence, knowledge, and know-how. Action is required to put good ideas into effect. Action does not initiate itself. It is initiated by organization members who are responsible for developing or applying the ideas. The path from the origination of a good management idea to the production of more goods and services of better quality at lower cost, is long and full of obstacles. It requires tenacity to stay with an idea in the face of difficulties and opposition. It takes courage to make the necessary decisions.[1] An executive's career may be set back seriously if his decisions fail to produce the desired results. He must make decisions and accept responsibility, nevertheless. No effective action will take place otherwise. Human understanding and a sense of justice are obviously necessary. The leader has an obligation to the led, as well as the led to the leader. He must give fair consideration to the interests of his subordinates, whether executives or operatives. He will forfeit their voluntary support if he does not.

The above discussion gives an interesting but incomplete analysis of why executives succeed. An equally interesting picture of executives who have failed can be drawn. There is the executive who insists about know-

[1] "Many men are sound thinkers, planners and administrators. They carry on effectively up to the critical point. Then they pause and wait for a superior—or the pressure of events—to push them into the final step that will produce action and get results." Rogers, Slade, and Hill, Management Consultants, in *Management Briefs*, No. 63, 1955.

ing everything about everything. His mind is fogged by detail. He loses perspective. He cannot see the broad picture. He may fail because of his inability to engage effectively in long-range planning. There is the young ambitious executive who is in a hurry to take over the president's job. He may be unwilling to spend the time on his present job to get the experience for the next higher position in his line of promotion. Some fellows are working for higher executive jobs chiefly because "there is money in it." There is no money in anything for a failure. One seldom succeeds in a job when he is not interested in it, except for the money. There is the chap who is going to get ahead, or else. He places his own interests ahead of the interests of the organization, or anyone in it. The methods by which he advances himself are usually ruthless, and often unethical. He may be able to advance himself by such tactics in a large organization. The closer he gets to the top, however, the better is top management able to see how he operates. The writer has observed a couple of cases of this kind. In both instances, the offending individuals were put out of the game on personal fouls, just as they were nearing their goals. There is also the fellow who has to retire at the peak of his career because of heart trouble or stomach ulcers. A common explanation of his case is "the pace of modern business." The real explanation is more likely to be a lack of understanding of good organization. There are many other possible causes of executive failures.

The principal difficulty with all such lists of leadership traits is the failure of the experts to agree. The reason is that there can be no general formula for executive success in terms of required leadership traits that must be present in predetermined amounts. The principal factors in a leadership problem are the leader, the led, and the particular situation. There are various kinds of leaders. There are those executives, for example, who rely largely on their authority to get results. They may exercise a negative leadership. By this is meant a leadership that motivates an organization by the negative incentive of fear. A negative leadership may be required temporarily during an emergency. Some negative leadership for disciplinary purposes is necessary in any organization. A church expels heretics or others who violate its laws. Disciplinary action should not be necessary, however, except occasionally and for small numbers of individuals. A general and continuing exercise of negative leadership will rarely produce maximum results. Subordinates are more likely to do the minimum of work that will avoid dismissal, rather than the maximum that they can do without overexertion. Automatic machine production will not overcome this loss entirely. Neither will penalities for failure to comply

with orders and directives, or other negative incentives. Any general use of negative incentives tends to limit *per capita* production. A positive leadership, on the other hand, relys on the motivation of opportunity and hope. It uses positive incentives for rewarding superior performance. It should be evident without further discussion that the traits of the executive who habitually uses negative methods will be different from those of the executive who uses positive methods. We can classify executives also by types of activity. We have sales executives, production executives, financial executives, personnel executives, purchasing executives, engineering executives, and others. The characteristics and qualifications that are required in an executive are determined basically by the requirements of his job.

We have noted previously the influence of the led on the success of the leader. The traits that would be required for the successful leadership of a group of professional operatives, such as engineers, are different from those that would be required for the leadership of a group of unskilled operatives. The effects of changing situations on the executive may be pronounced. The leadership requirements for a concern in a rapidly growing industry, such as certain fields of electronic equipment, are different from those for a concern in a "mature" or a dying industry. It is sometimes necessary to relieve a top management that has been successful during a period of inflation, when we enter a period of deflation. It can hardly be due to a lack of experience with the company and its products. The writer saw a number of instances during World War II in which executives failed who had been successful during peacetime. Conditions of wartime manufacturing had set up executive requirements that they could not meet.

We can not ignore the problem of executive selection and development because we are unable to write a general specification for executives that will cover accurately every executive job. We made a distinction, in Fig. 2.1, between executive leadership, and the executive. The latter is an employee of the company, regardless of his grade. We distinguished also between the executive and the function of executive leadership, management. Leadership is a vital force in organization. It stimulates, motivates, and coördinates the organization in the accomplishment of its mission. This force is generated initially by competent leaders using good management methods. There is a principle that has been called the law of the situation. It says: Effective leadership depends on the executive's ability and courage to face the facts in the situation, interpret the facts properly in the light of the situation's requirements, and follow the course of action

that they dictate. The success of the organization depends on effective leadership. Many large organizations have executive development programs for this reason. They cannot write formulas for executive success any better than we can. They can determine the basic knowledge requirements for executive success in their company and industry. They can analyze the requirements of existing executive jobs in the organization. They can do many other things that will aid in developing a supply of competent executives of all grades. We shall discuss some of them when we take up the problem in connection with the work of personnel management.

Business Policy

The term policy is frequently used without definition in discussions of business problems. This makes it necessary for the participants in the discussions to formulate their own definitions. Policy is a basic factor in business decisions. Differences of opinion as to what policy is, and what it does, can cause much loss of time, unnecessary disagreements, lack of coöperation, and poor coördination. Some unity of understanding is necessary before the members of an organization can agree as to what a specific policy should be and do in a particular situation.

A business policy is basically a principle, or a group of related principles, with their consequent rules of action, that condition and govern the achievement of certain business objectives. A principle is a statement that is accepted as true in the present state of our knowledge, which sets up a meaningful relationship between cause and effect. The effect in business organization is the business objectives that must be accomplished. The cause is work. The functions of the business organization are the work that it does. The work that must be done is determined by the values that the organization must produce and distribute. The requirements for an effective, economical performance of this work determine what men, money, materials, machines, and methods must be used. Policy is obviously a linking factor. It provides a meaningful relationship between business objectives and ideals on the one hand, and organizational functions, physical factors, and personnel on the other. It governs, accordingly, the managerial work of planning, organizing, and controlling, as well as the operative work of doing or making.

A policy has two principal parts, as indicated by the above definition: the principle that governs, and the rule that indicates the general manner of its application. The principle is the basis of the "reason why" that gains acceptance of the policy. The rule "lays it on the line." It is the basis of

opposition to the policy, when it stands by itself. We may have a policy governing tardiness among hourly rated employees, for example. It may say: "An hourly rated employee shall be docked 10 minutes pay for each 5 minutes that he is tardy." This is the rule. It may cause resentment, if nothing further is said. It may give outsiders an excuse for charging management with "exploiting the worker." The rule may be preceded, however, by some explanation, such as the following: "The success of the organization, as well as security of employment, depends on a continuous flow of customer orders. It is the customer who provides work. His patronage depends on the organization's ability and willingness to give good customer service continuously. Good service includes cost and delivery as promised, as well as the quantity and quality of the goods that are specified in the order. The tardiness of hourly rated employees interferes directly with production. Any interference tends to increase production costs and break down production schedules. The following rule must be applied for these reasons." This is an explanation based on what the particular management believes to be sound operating principles. A particular employee still will not enjoy being docked. A majority of the employees may accept the rule as reasonable, however, because of the reasons stated.

Policy is important because of the contributions that it makes to effective, economical operations. It tends to prevent deviations from planned courses of action, because it makes possible an intelligent understanding of plans. It insures consistency of action, because the organization is always guided by the same basic principles in planning, organizing, controlling, and executing its work. It promotes intelligent coöperation and facilitates coördination, for much the same reasons. It fosters an intelligent exercise of initiative, because it provides a body of principles and rules for the analysis of situations. It provides a guide for determining equitable personnel relations, as suggested above. It provides obviously a guide for executives in their performance of the work of management. It furnishes a basis, therefore, for evaluating the quality of the leadership of subordinate executives by higher executives to whom they report.

It is evident that policy-making is an executive function. Top executives spend much of their time in making broad, basic, general policies. These policies are intended to govern the organization as a whole for a long time. Within the broad framework of such general policies, major executives may make major policies for the guidance of the major divisions of the organization that they head. Minor executives, similarly, make rules

for their departments or other subdivisions, within the framework of divisional policy.

We have noted previously that the characteristics of policy are determined by the requirements of objectives, on the one hand, and the functions that must be performed in their accomplishment on the other. So we may classify policies, on the basis of functions, as sales policies, manufacturing policies, financial policies, engineering policies, personnel policies, and others. It is evident that some of these policies are line policies, since they have to do chiefly with primary functions. Engineering, personnel, credit, purchasing, and certain other classes of policy are staff. They do not enter directly and immediately into rendering customer service. We have referred previously to public relations policies. It is true that good community relations depend usually on good employee relations. The direction of public relations policies is fundamentally outward from the organization, nevertheless. We may classify policies, accordingly, as internal or external with respect to the direction of their influence.

The executive who has practical experience often uses such classifications informally in policy making. They suggest the specific requirements and characteristics of a policy for a particular problem situation. They rest on certain general requirements and characteristics of any policy anywhere. Some of them have been noted previously. It will be recognized, in addition, that a policy should have reasonable stability and flexibility. Otherwise, our organization structures and methods are likely to be unstable and inflexible. A policy must be derived from some fundamental principle or principles, to give it both stability and flexibility. We do not want policies that break down with every minor change in the objectives and characteristics of the business. We want policies that will serve effectively as a guide for sound management decisions under all normal variations in the volume of our business. Our body of policy should be comprehensive also. It should furnish a basis for decisions covering all action that normally would be required. This does not mean a large body of rules that anticipate every conceivable situation. On the contrary, it means the smallest number of broad, fundamental statements of principle that is practicable. It should be remembered also that the executive who formulates a policy may not be the person who applies it. The latter person, furthermore, may operate on some organizational level that is far below that of the executive. It is probable that he does not have the executive's background and breadth of view. The policy should be stated in simple, understandable terms, for this reason.

There is no formula for solving policy problems. It is helpful, nevertheless, to break down the problem of policy making into its elements, as follows:

1. Policy formulation
2. Policy promulgation
3. Policy education
4. Policy acceptance
5. Policy application
6. Policy interpretation
7. Policy control

Policy formulation has to do with the selection and statement of the principles and rules of action that are to govern a particular type of activity. A policy can have no force or effect until the people who should apply it at least know of its existence. Policy promulgation is the function of getting the policy down to the levels in the organization where it is to be applied. It does not follow, however, that a clear understanding of the policy is assured merely by placing a clear statement of the policy in the hands of those who should be guided by it. This often requires education in some form. We may use conference training or other techniques to accomplish this end. An understanding of the meaning, significances, and requirements for effective application is one thing. Acceptance of the policy as fair and workable is something else. Understanding without acceptance means that we shall have only lip service to the policy. Acceptance may develop directly from the educational phase. It may come from demonstration within a limited area of operations. It may come from experience with use. Application means just what it says: putting the policy into effect. Policy interpretation is the function of clarifying the meaning and significance of the policy as it relates to a particular situation. It may become necessary immediately before, during, or immediately after attempts to apply the policy. Policy control has to do chiefly with determining the effectiveness of the policy under conditions of use, and the degree of conformity with it. It depends on an analysis of facts concerning the application of the policy. These facts may be secured through personal experience, staff investigation, routine operative reports, difficulties that are reported in executive conferences, formal complaints and suggestions, and other means.

It is easy to see why policy is generally regarded as a basic business problem. We shall look shortly at the principles underlying the work of various line and staff groups. It should be remembered that these principles are the basis of policy governing their work.

Business Functions

It was noted previously that objectives are values. Business objectives include those values that the business organization must supply to customers, owners, and others associated with the business. It includes also values that must be supplied to the organization itself for the accomplishment of its mission. The primary objectives of the organization are those economic values with which it serves its customers. Values are created by work. The effort required for this work may be mental, manual, mechanical, or some combination of them. The term "business function" refers merely to some particular work that is necessary for the accomplishment of the organization's objectives. The primary determinants of business functions, then, are the requirements for a satisfactory competitive accomplishment of primary service objectives. Wages, salaries, other business expenses, and taxes come out of the sales dollar. A profit is what is left, if anything.

Organic Business Functions

Henry Ford, Sr. was one of a number of great industrialists of the past who symbolize the American tradition. He built a great industrial empire, starting almost literally from nothing. The birth of this empire took place in a small machine shop in Detroit in 1893. It was practically a one-man manufacturing plant. It was necessary for Mr. Ford to perform personally all the functions of the business, with the assistance of a few mechanics. Little more than a half-century has passed since then. The Ford Motor Company supports today approximately 148,000 executive and operative employees throughout the United States. The business of the company has become vast and world-wide in scope. Its principal functions are still the manufacture and distribution of automotive vehicles to the public. The chart in Fig. 2.3 gives a simplified picture of the company's organization in 1957. It shows that work and work relationships have become very complex within it. The same story, with appropriate modifications, could be told for many of our great American corporations. Most business organizations, however, do not start their growth and development with a single proprietor. An understanding of organization requires a brief discussion of what takes place when they do, nevertheless.

We shall assume that the owner-manager-operator of a one-man manufacturing business is successful. His sales and the amount of work that he has to do will increase. A time will come, if this continues, when he cannot handle it all personally. He will do the obvious thing when this

happens: hire someone to help him. He may hire a mechanic to help him make the product, a salesman to help sell it, and eventually a clerk-stenographer to help him with such simple records and accounts as may be necessary. The structure of the business organization may look now like that shown in Fig. 2.4. It is simple, but something significant has taken place. The owner-manager, without knowing anything about the theory of business organization, has made a separation of managerial from operative work. This means, roughly, the separation of mental from manual work. He has merely done what comes naturally. He has kept the managerial functions for himself, and probably the operative functions requiring the greatest skill and know-how. He recognizes that they are the most

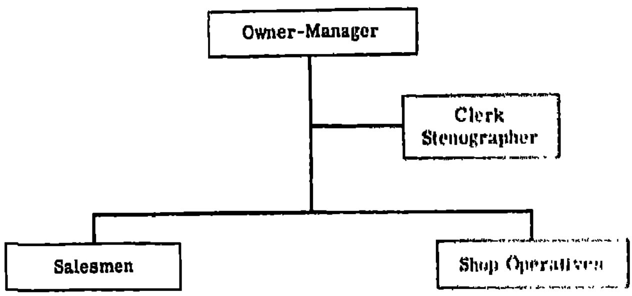


Fig. 2.4. A Small Shop Organization

important in the success of his business. He has assigned the remaining operative functions to the salesmen, the shop operatives, and the clerk-stenographer. These operative functions involve no responsibility for the direction and supervision of others. So another significant development has taken place: the owner-manager has acquired a leadership responsibility.

The most significant development is the distinction that has been made between the operative functions. It has resulted in the initial separation of the organic functions of the business. These are functions whose performance is vital in a major business field. Activity will cease unless they are performed somehow, somewhere, at some time, by someone, in the minimum degree required for the satisfactory achievement of primary service objectives. The reason is obvious, perhaps: the business organization is an economic institution. Its mission is to supply economic goods and services to the consuming public. These goods enable the customer to enjoy certain satisfactions of his needs and desires. These are the real values that he buys, as we have seen. The utility of the good or service is its

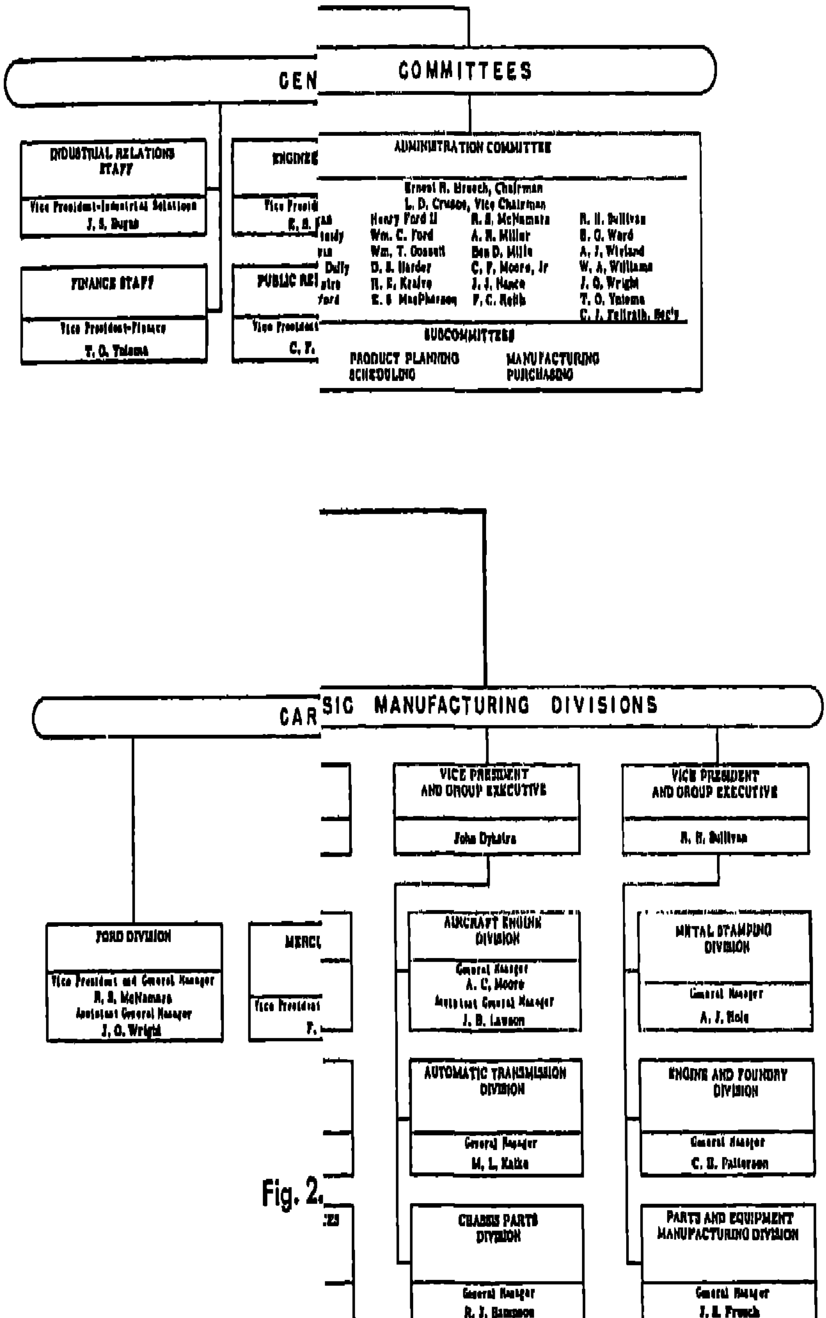

COMMITTEES
INDUSTRIAL RELATIONS STAFF
Vice President-Industrial Relations
J. S. Bugas
FINANCE STAFF
Vice President-Finance
T. O. Yntema
ADMINISTRATION COMMITTEE
Ernest R. Breech, Chairman
L. D. Crusoe, Vice Chairman
Henry Ford II
Wm. C. Ford
Wm. T. Gossett
D. S. Harder
R. E. Kralve
E. S. MacPherson
R. S. McNamara
A. R. Miller
Ben D. Mills
C. F. Moore, Jr
J. J. Nance
F. C. Reith
R. H. Sullivan
B. G. Ward
A. J. Wieland
W. A. Williams
J. O. Wright
T. O. Yntema
SUBCOMMITTEES
PRODUCT PLANNING
SCHEDULING
MANUFACTURING
PURCHASING
SIC MANUFACTURING DIVISIONS
VICE PRESIDENT AND GROUP EXECUTIVE
John Dykstra
VICE PRESIDENT AND GROUP EXECUTIVE
R. H. Sullivan
FORD DIVISION
Vice President and General Manager
R. S. McNamara
Assistant General Manager
J. O. Wright
AIRCRAFT ENGINE DIVISION
General Manager
A. C. Moore
Assistant General Manager
J. B. Lawson
AUTOMATIC TRANSMISSION DIVISION
General Manager
M. L. Kalka
CHASSIS PARTS DIVISION
General Manager
R. J. Hampson
METAL STAMPING DIVISION
General Manager
A. J. Hole
ENGINE AND FOUNDRY DIVISION
General Manager
C. H. Patterson
PARTS AND EQUIPMENT MANUFACTURING DIVISION
General Manager
J. E. French

Fig. 2.

ability to provide these customer satisfactions. This ability is affected by such basic considerations as time, place, form, and possession. It is deter- mined by certain characteristic attributes of the good or service. We are accustomed to refer to them in manufacturing as the quality attributes of the product. It is evident that we cannot serve the customer unless we create these utilities in our goods or services and distribute them to the public. But we live in a highly developed industrial society. We do busi- ness on a large scale over great areas in every major field of business activ- ity. Capital is productive. It is represented by materials, merchandise, equipment, the services of people for which we must pay, and many other things in addition to money. Even a little one-man business could not exist long without some capital. It follows then, that there are three organic functions in every business field. They are the work of creating certain utilities in our goods or services, distributing them among our customers, and providing the capital, without which the first two cannot be performed.

Organic business functions have fundamental significance, because all subordinate functions come from some one of them. They are represented by the major line divisions of the organization. All staff groups come initially from these line divisions. It is necessary, therefore, to identify these organic functions. There are four simple tests that make this rela- tively easy: (1) The function should meet the test of universality. An inspection of the organization charts of the leading companies in an industry will show whether or not it is found universally. (2) The con- tribution of the function must be basic and vital. The function may be important but it cannot be organic if customer values can be created without it. (3) The continued downward growth of the function, as more work has to be separated for new work assignments, leads to primary operative specialization. No staff function can meet this test by itself. (4) One organic function cannot be combined directly with another organic function. An attempt to do so leads back to one-man organization. The reason is that such functions make contributions that are basically differ- ent. They require, therefore, basically different abilities and character- istics in the people who perform them.

There is nothing theoretical about the concept of organic business functions. They can be identified easily in every major business field. They are not identical for every field, however. They are the functions of pro- duction, distribution, and finance in the field of manufacturing. They are something else in the distributive, transportation, banking, communica-

tions, and other industries. They rest in every major business field on the economic concept of utility, nevertheless. The only organic function that appears to be universal in all major business fields is finance.

The Differentiation and Grouping of Functions

The organization must expand as its volume of business increases. Its work must be broken down, separated, analyzed, and then grouped in assignable work units. The unit may be large when it has to do with an important division of a company. It may be small when it involves only the performance of a step in completing an operative project. This step, for example, may be an operation that puts a finished surface on a particular part. Many operations may be required to complete the part. It may be assembled then with other parts to make a subassembly of the end product. A number of subassemblies, together with certain other parts, are assembled together to make the end or finished product. It is the business of the company to make and sell these products. It is evident that the primary function of the company has been broken down and separated many times into many work assignments at various levels of the organization. The work of performing the finishing operation on the part, mentioned above, may not take up all of a workman's time. We shall assume that this work was authorized originally by a production order, calling for 50 finished pieces of the part. The finishing operation on the part may require only 2 hours of the workman's time. His time goes into the cost of production. It is necessary to assign to him other work of performing other operations on other parts. Otherwise we shall not occupy his time constructively for the remainder of his work day. This workman has a general work assignment, or job. It falls within a classification or grade of work. There is probably a job specification covering the nature, conditions, and requirements of his general work assignment. The operative is presumed to be competent to perform any work that falls properly within his job classification and specification. The work of performing the finishing operation on the 50 pieces was a specific work assignment. It fell within the job classification. A specific work assignment has to do with the completion of a project, or some phase of it. The project in this case was an order for 50 pieces of the particular part. We shall see later, when we discuss the work of motion and time study, that probably there is a methods specification for the finishing operation. This specification prescribes the methods, conditions, and time required for the proper performance of the operation. It may break down this work in great detail. The process of separating functions for the purpose of regrouping them in

assignable work units, either general or specific, is known as functional differentiation. It takes place wherever there is a substantial increase in business volume. Such an increase makes necessary a further division of labor and provision for specialization. It may be necessary, for example, to make changes in organization structure to handle a marked seasonal increase in business volume. Such changes are usually temporary, however.

It is evident that the reverse of the process may take place. What happens when we have a business depression? The amount of work that is available to the organization may be diminished greatly. It may be necessary to recombine general work assignments to some extent. We do not need the same division of labor and specialization as we did previously. It may be necessary to reduce the number of different jobs and our break-even point. There will be no jobs for anyone, if the company fails financially. This process of recombining functions, with a declining volume of business, is known as functional integration.

Similar and Complementary Functions

We shall assume that Fig. 2.5 shows some of the lower levels in the above organization. We need not be concerned at the moment with the distinctions between administrative and operative management. It is sufficient to know that managerial functions are the work of executive leadership. Both operative and executive functions are work that result in the creation of values. Operative functions, however, do not involve responsibility for the direction and supervision of others. Primary operative functions result immediately and directly in the creation of salable values.

The work of the organization, shown in Fig. 2.5, has been broken down and separated in some degree as noted previously. Various functions have been grouped together on some basis to permit a division of labor and promote specialization. The result has been, evidently, the development of a simple organization structure. It will become more complicated, undoubtedly, with further growth in the company's business. Any organization structure for any organization of any size is basically a relationship of functions, nevertheless. It is set up to promote coöperation between the individuals and groups composing the organization. It facilitates the exercise of executive leadership. It contributes greatly, for these reasons, to an effective, economical achievement of the organization's objectives.

There is a principle of functional similarity that guides us in differentiating and grouping functions for organizational purposes. It says merely: Operating economy and effectiveness is greater usually when the organizational components are formed by grouping similar functions together.

Similar functions may be defined as those that have like objectives and work characteristics. They give rise in consequence to similar problems. These problems involve similar factors, forces, and effects. They require similar background, training, experience, intelligence, and personality in the personnel assigned for their performance. It is evident that if two functions were exactly alike in all these respects, they would be identical. An organizational component is a group of functions, together with the

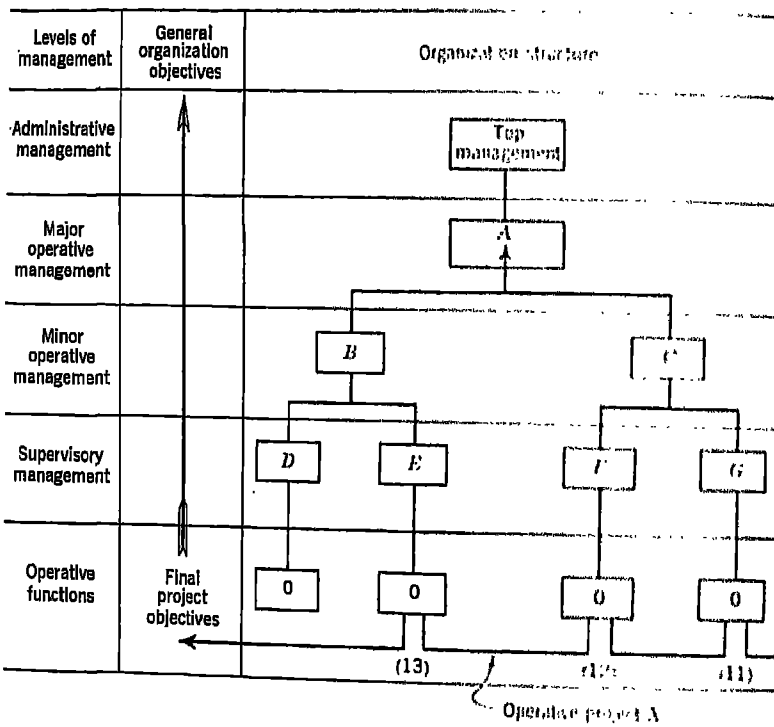


Fig. 2.5. Relations Between Similar and Complementary Functions

personnel and facilities that are necessary for their performance. Supervisors D, E, F, and G are in charge of small supervisory units. They report to their department heads, B and C, as shown in Fig. 2.5. A is in command of the latter departments, and probably certain others that are not shown. He is accountable to higher authority for their work. His group of departments is probably a major division of the organization. The importance of grouping such organizational components with due regard for functional similarities will be evident when we look shortly at the problem of responsibility.

We observed, previously, an operative who was performing a finishing operation on an order of 50 pieces of a particular part. We shall assume that the order is Project X in Fig. 2.5, and that the finishing operation is operation 13 on the particular part. The operative must be a member of Group E, obviously. It is evident that operation 13 cannot be performed until the 50 pieces have been received from Group F. Operation 12 was performed in this group. Operation 11 must be performed on the lot of 50 pieces before operation 12 can be performed. What is it that establishes the nature and content of these operations, and the order of their performance? It is basically the utility, or utilities, that must be built into the part. It is chiefly a form utility. The part must be able to perform certain mechanical functions in the finished product. It must be able to perform them, in mechanical combination with other parts, in a manner that will give the customer the satisfactions for which he pays. The characteristic attributes of the part, that enable it to perform these functions satisfactorily, are its quality attributes. The final objective of Project X is satisfactory performance of the mechanical functions of the particular part. The first step in making the part, shown in Fig. 1.2, was machining one of the "holding" or "reference" surfaces for the blank from which the part was to be made. All subsequent operations for creating linear or other dimensions in the part were made with reference to these surfaces. One purpose was interchangeability between parts in final assembly. There must be, again, some finishing operations in the production of this part. They do the final job of creating the required form utilities in the part. It is then subjected to final inspection. This may include various tests to assure that the part can meet satisfactorily the requirements of its final objectives. We shall get a more clear-cut picture of such tests when we look later at the work of quality control. Our interest at this point is chiefly in discovering what has happened to the work of the organization at the operative level. It is evident that it has been separated and grouped in logical steps that enter into making, doing, or accomplishing an operative project. Any business procedure also is a structure of relationships between functions, physical factors, and personnel. It is set up, however, for the purpose of coördinating and facilitating the accomplishment of some type of project. It does this by arranging logically the order of performance of the functional steps of the procedure. This arrangement must facilitate a build-up of values into an effective, economical accomplishment of the final objectives of the project. It is based, therefore, on the complementary and sequential characteristics of functions, physical performance factors, and personnel as they enter into such accomplishment.

Steps 11, 12, and 13 in Fig. 2.5 are evidently groups of primary operative functions in a procedure for making part X. Managerial procedures are largely staff procedures. Much the same thing could be said for them. In either case, complementary functions are those that must be performed concurrently or sequentially, in a definite order, to accomplish successfully the final objectives of a project. But step 13 on Project X was merely a specific work for an operative in Group E. It took only two hours of his time. The remainder of his time, during the working day, was spent on other operations on other projects. These jobs also fell within his general work assignment. It is evident that any function of a business, whether managerial or operative, may have both similar and complementary characteristics.

PROBLEMS

1. The Trutone Company was a producer of radios, console and table models, and automobile radios. Prior to World War II it had the distinction of being one of the top firms in the industry, producing approximately 25% of all console and table model radios, and supplying 40% of all automobile radios installed by manufacturers. During World War II production of all lines for civilian consumption was completely halted. Production facilities were devoted to radio and allied equipment for the armed forces. Following the end of the war, the radio market was virtually flooded by such products. There were a number of new concerns in the industry. Some had obtained surplus government equipment in order to enter the radio and electronics field. Meanwhile the Trutone Company had returned to production of its original lines with designs similar to those which had proved so successful before the war. The president declined to approve large research budgets because of his satisfaction with previous success of the company. He felt also that the firm had ample opportunity to improve its position with the equipment and ideas which remained as a result of its government contract work. Among the many competitive offerings were many varieties and designs of portable radios, automobile radios, and also new models of short-wave radios and other lines: sale of these represented an increasing share of the market. The company suffered a serious setback when several auto firms turned to new sources of supply for their auto radios. Increasing pressure on dealers to sell its product brought complaints of consumer resistance to the product, and several dealers ceased carrying the Trutone line. It was only after several years of declining sales volume that a change in policy was effected. The company's share of the market declined to about 10% during this time. The new policy placed considerable emphasis on research and product development. The company was able to regain some of its lost position in the industry.
   (a) What basic business factors, such as objectives, policies, and others were not given adequate consideration in the above case?
   (b) What principles of good management were violated?

2. The president of a company believed that a personnel department should be set up in view of reports relating to labor turnover and morale. Strong opposition developed among some of the major production executives. They felt that the foremen would resent such a development as an encroachment on their prerogatives, and that this might cause even more trouble. The president yielded to these objections. Subsequently, labor troubles caused serious loss to both employees and the company. The sound advice and assistance of a competent personnel staff might have eliminated at least some of the causes of these difficulties.
   (a) What fundamental law of leadership did the president violate? What other fundamentals of organization may not have been given due consideration?
3. The works manager of a manufacturing plant recently received a request from the employees' shop committee for permission to use the departmental bulletin boards for notices concerning the activities of a shop employee's organization. The works manager replied as follows:

   "The Plant Executive Committee has considered the complaint that our policy forbidding the posting of any notices except those that relate to company business, interferes with the work of your Committee. It realizes that the effectiveness of the Committee depends on its ability to keep the employees informed of its activities, and that the bulletin boards offer an effective and convenient channel of communication. Inasmuch as the activities of the Committee affect the welfare of the company's employees, its activities may be considered company business, in so far as the intent of the above policy is concerned. Therefore the use of the bulletin boards is extended to your Committee. It is expected that regulations governing the use of the boards will be worked out by agreement subsequently.

   "In the meantime, Committee notices will be handled as follows to assure orderly use of the boards. The secretary of the Employees' Committee will give such notices to the company's Personnel Manager. He will see that they are posted on the department bulletin boards immediately. Such notices will be taken down at the end of three days, unless specific arrangement for a longer period is made with the Personnel Manager's Office for a particular notice. All factory executives will be notified at once of this change in policy.

   "The Management is most anxious to maintain the friendly relations that have existed between it and the employees. You may be assured that it has no desire to hinder the Committee's work in any way."
   (a) Analyze the above letter with regard to the characteristics and requirements of sound policy. What principles and rules of action constitute the policy?
   (b) What basic business factors have been considered in formulating it?

CHAPTER 3 •

• Management Responsibility and Authority

Scientific Management

THE first step in the development of an organization from the one-man stage is taken when the owner-manager-operator hires the first helper. It represents the first stage in functional differentiation. It marks the beginning of the separation of managerial from operative functions. The differentiation of both basic types of work continues with business growth. It results eventually in a relationship of functions that is basically like that shown in Fig. 3.1. The major line and staff divisions of the company have been differentiated from the organic functions of the particular industry, as noted previously.

Management has been defined as the function of executive leadership. It is a universal function because no organization can accomplish its objectives effectively and economically without leadership. The quality of management varies greatly between companies, nevertheless. Older writers in the management field distinguished frequently between kinds of management on the basis of the developmental methods employed. The usual distinction was between conventional, systematic, and scientific management. Conventional management solves its business problems chiefly by the method of trial and error. Most organizational and procedural problems can be solved eventually by this method, provided that the rate of change in the business situation is slow. It is usually the most expensive and time-consuming method. It is likely to be the most hazardous under competitive conditions, because it involves little advance planning. Systematic management is chiefly imitative management. The executive leadership of a company may realize that some of its methods are not satisfactory; that there are better ways of solving some problem that is particularly troublesome. It may, accordingly, send out a team to call on other manufacturers to find out how they are handling the problem. The American manufacturer is usually quite generous in giving away

management information. It is quite probable that the team will be shown through the plant that is being visited. It will be given the information that it requests, if there is any legitimate reason for it. Our company may send a member of the staff that is studying the particular problem to a seminar, or school, to discuss it and related problems with executives from other companies. Our team will survey current periodical literature, undoubtedly, to determine further what is current practice in handling the problem. These methods are excellent when the members of the team and

Basic Kinds and Grades of Organizational Service			Major Organizational Divisions	
			Line	Staff
Managerial Service	Administrative Management	Planning, Organizing and Controlling the Work of Others	(Duties)	(Duties)
	Operative Management		(Duties)	(Duties)
Operative Service	Professional	Planning, Organizing and Controlling One's Own Work	(Duties)	(Duties)
	Skilled		(Duties)	(Duties)
	Semiskilled		(Duties)	(Duties)
	Unskilled		(Duties)	(Duties)

Fig. 3.1. Managerial and Operative Functions

the responsible executive have an adequate professional background in management. Otherwise it may be a case of the halt leading the blind. The dangers of the systematic method are obvious: the methods of other companies may deal with the same problem, but they were developed under different circumstances. They may not meet the requirements of our situation without extensive modification. The system may be made to work eventually, as a result of modification by trial and error. It is likely to be less effective and more costly than the original method in its original setting. This writer observed some serious failures during World War II. Some of them resulted from an exchange of excellent information, in good faith, between men who were practical business mechanics, rather than professional executives.

Much has been written about scientific management. There is still considerable misunderstanding concerning it. A science may be any classified

body of fundamental facts, principles, and techniques. It explains certain basic phenomena. It leads to the discovery of general truths and the operations of general laws. A scientific method may be any method that applies a logic of effective thinking, based on an applicable science, to the solution of a particular set of problems. Management is a leadership function. Its performance is based on inexact social sciences, as well as the exact physical sciences. Scientific management is not a complicated, theoretical, and costly system. It is an approach which seeks to apply the logic of effective thinking, based on a management science, to the solution of business problems. It is evident that it must rest on a sound philosophy of management. Effective, economical solutions of business problems require the practical application of a sound, logical management philosophy.

Some executives have no management philosophy of any kind. Scientific management must remain impractical for them, since they lack what it takes to practice it. Such executives run the risk of elimination by competition.

Organic Management Functions

Organic business functions break down, with increasing business volume, into managerial and operative functions. Management is a universal function. It breaks down also into its organic functions. These are basic leadership functions that must be performed in or for the organization. Otherwise it ceases to function economically and effectively. Various authorities have offered analyses of the management function. They boil down, usually, to a least common denominator of three organic management functions; creative planning, organizing, and controlling. *Creative planning* is the work of determining and specifying originally the factors, forces, effects, and relationships in the accomplishment of designated objectives. *Organizing* is the work of creating in advance the basic conditions that are a prerequisite for a successful execution of the plan. These may include plant, people, leadership, sound organizational relationships, and any others that may be necessary. *Controlling* is the work of constraining and regulating the activities of the organization in accordance with the requirements of the plan. We shall take a closer look at these functions shortly. It should be noted here, however, that all executives perform these functions to some extent whether they are administrative or operative executives, line or staff. Each organizational group has, or should have, its assigned mission. The requirements for successful accomplishment differ accordingly between groups. This sets up necessarily some important differences in leadership requirements. Nevertheless, the

work of management differs between groups chiefly with respect to its specific characteristics and requirements, rather than its basic nature.

An analysis of the organic work of management is usually included in executive development programs. It makes some very practical contributions to executive effectiveness: (1) it provides the basis for a common understanding of what is the work of the executive; (2) it provides the basis for a logical development of staff organization. There is usually more coöperation, greater effectiveness, and less friction between executives when they know what is the basis of their work and their relationships with other executives. The significance of management functions in staff organization will be seen shortly when we discuss the nature of organization structure.

Administrative and Operative Management

Figure 3.1 suggests that a distinction must be made between administrative management and operative management. Administrative management is group management. It is concerned chiefly with planning, organizing, and controlling the work of organizational groups or components over a period of time. The work of administrative management must be performed at every level in some degree. The group may be the sales division or a production department. The time period is usually a month or longer. It is the principal work, however, of general executives, such as the president, the executive vice-president, divisional and staff vice-presidents, and general managers. This is why administrative management is often called general management or top management. This work will be discussed when we examine later the functions of the industrial organization.

Operative management, in its simplest terms, is project management. Both executive and operative employees produce necessary and usable values, or they are nonproductive. Primary operative employees are those whose work results directly and immediately in the creation of salable values. Staff operatives produce secondary or collateral values. Operative work does not involve any substantial responsibility for the direction and supervision of subordinates. Operatives have only personal responsibility for a satisfactory accomplishment of assigned work. Clerks, machine operators, salesmen, professional operatives, or any nonexecutive personnel are examples of operative employees. Such operatives work usually under the direction and supervision of a supervisory executive. He coördinates their activities in completing assigned work projects. These projects may be the accomplishment of sales objectives for assigned territories,

production orders to be completed, invoices to be checked, or any other specific operative work assignment. Operative executives have leadership responsibilities for the work of groups of operatives. Group leaders, for example, may report through assistant foremen and foremen to general foremen or shop department heads in a factory. Unit chiefs may report through branch chiefs and section chiefs to a department head in the office.

It is evident that supervisory management is largely departmental management. Departmental executives are minor operative executives. They are concerned largely with controlling the execution of operative projects, but they may have minor responsibilities for project planning and organization. There may be a number of grades of supervisory executives. Above them are major operative executives, such as superintendents, plant staff heads, plant managers, and others. The field of major operative management shades into the field of minor administrative management. There are no sharp dividing lines, such as we have been compelled to use for graphical reasons in Fig. 3.1.

Some concerns reserve the term "executive" for use by top management. They tell their first-line supervisors, at the same time, that they are on the "management team," which is correct. The distinction is not too logical, however. Management is the function of executive leadership anywhere.

Creative Planning

Organizational action that is consistently successful over any long period of time depends on sound plans. This is true of any organization of any kind, anywhere. Creative planning is generally regarded as an organic management function for this reason. It involves the original determination of the answers to such questions as what should be done, how it should be done, where should action take place, who should be responsible for it, and why. The result of planning is obviously some type and kind of business plan for the solution of some business problem. It is a specification in any case of the factors, forces, effects, and relationships that enter into and are required for the accomplishment of a designated objective. A plan supplies, accordingly, a basis for effective, economical action for the execution of the mission.

A plan tends to break down into two principal parts: (1) the general plan for the organization that will make possible the solution of the particular problem and (2) the various detailed plans that support it. The latter may be developed by staff groups that are specialists in

particular phases of the required action. An initial and tentative determination of the organization's primary service objectives for a coming period, for example, is frequently the starting point for business planning. The initial sales forecast for the company may be made by the marketing research group and the sales division. Product and process plans, however, will be made initially by our engineering division, personnel plans by our personnel division, procurement plans by our supply division, etc. We shall look briefly at some of this detailed planning when we discuss the work of the various staff groups in the industrial organization. It is sufficient to note here that such detailed plans must be tied together in a general plan for the organization. Otherwise the organization will lack a common basis for coöperation, and the coördination of the various group activities in the accomplishment of the common mission.

The Requirements and Characteristics of Business Plans

The business plan should meet certain general requirements. The following are the more important:

1. It should state the nature of the mission and its objectives. It should facilitate, accordingly, an understanding of the mission by giving a reasonable explanation of it, with due regard for organizational security. We cannot expect coöperation and intelligent initiative in the execution of the plan when subordinate personnel do not understand or believe in it.
2. It should provide measures of a satisfactory accomplishment of the objective in terms of quantity, quality, time, and expense, or indicate where they may be obtained. Otherwise, it is difficult to delegate responsibility, measure results, and assess accountability for the accomplishment of the mission.
3. It should state the policies that should guide the thought and action of the organization in accomplishing the mission, or indicate where they may be found.
4. It should indicate the principal phases or subfunctions of the activity by organizational areas. It may or may not go into the details of procedure for performing the required work. This depends on the organizational level at which the work of planning is being done.
5. It should indicate quantitative time requirements and time relationships for each phase of the activity. It does not indicate target dates, although the determination of the final completion date for the undertaking may be necessary. The conversion of quantitative time to chronological time is a part of the scheduling phase of the control function.
6. It should specify in kind and amount the allowable man power and other expense factors. The allowances should be adequate, but a minimum. Fair competitive prices less costs may equal a fairly good loss, otherwise. Some of the principal problems that affect the proportioning of performance factors have to do with money, markets, machines, methods, materials, and men.

7. It should designate the executive leadership that will be held accountable for the accomplishment of the mission, and each phase of it. Adequate responsibility and authority should be delegated to each accountable executive.

A sound business plan usually has certain characteristics. These have to do with objectivity, clarity, logical soundness, futurity, flexibility, stability, comprehensiveness, completeness, and simplicity. It is evident that the statement of the plan and its requirements should not be colored or distorted by bias or emotionalism resulting from undue emphasis on personal objectives within the organization. Otherwise we may accomplish certain personal objectives rather than the mission, to the ultimate detriment of both. The statement of the plan should be free from ambiguities. A plan should be definite, clear, concise, accurate, and logical to gain understanding and acceptance.

Planning for the past is the privilege of historians. Planning for the present is merely making decisions for expedient action. Free competition requires planning for the future. Executives must anticipate and provide for new needs of more people for more goods of better quality at relatively lower prices. Business forecasting accordingly, is an important function of the business organization. It takes time to plan and provide the factors in production. The time span between the initiation of new product planning and first deliveries to dealers may be from 6 months to 3 years, in the case of durable consumers' goods. The required lead time may be even longer in the case of some producers' goods. There have been cases in which a company has accepted an order at an unprofitable price during a depression, to hold its organization together. Such a contract tends to keep the company unprofitable during the following period of prosperity, because of the long lead time on delivery.

We have various methods for correcting the accuracy of forecasts and plans as we progress through time. The accuracy of business forecasting is still limited, nevertheless. Our plans must be sufficiently flexible, therefore, so that they can be adjusted quickly and smoothly to changing business conditions. We may set up alternative plans, or courses of action, in the event that certain possible conditions or contingencies arise. We specify the maximum deviations from the planned course of action that can be permitted without risking a breakdown of the plan. We refer to these permissible deviations as "limits," "tolerances," or "variances." A plan can be no more flexible than the people who are responsible for its execution. So our personnel department may have a job of broadening

the background and experience of our personnel. There are other considerations in the development of flexible plans.

Stability enables us to avoid the necessity for fundamental changes in long-range plans, because of changes affecting the secular trend of our business. These changes may result from fundamental technological developments, population shifts, basic changes in the buying habits of the public, and other causes. Plans are more likely to be stable when they are made by competent executives in a stable organization; when these executives have related their plans to the ultimate objectives of the organization. Careful consideration must be given to the secular trend of the business, of course. Long-range plans tend to be general rather than specific. They represent usually an application of sound general policies to the accomplishment of ultimate organizational objectives. These are other factors that may affect stability. Plans may be regarded as tools of management. Effective use of a tool usually requires the development of an understanding of its possibilities and requirements, through continued use. Plans must have some stability for this reason.

The plan should cover adequately all action that will be required of individuals and organizations in the accomplishment of the objective. It should be reasonably complete as well as comprehensive. It is meant by this that the plan should provide the necessary information for effective execution, or indicate how and where it may be obtained. Comprehensiveness does not require the plan to cover all action that may conceivably be necessary. It requires merely an adequate basis for all action that is covered by the plan. Too much detail usually reduces the effectiveness of a plan. It adds to its complexity and reduces its flexibility. The maximum practicable simplicity in plans is a virtue. Execution takes place usually on lower echelons of the organization. It is carried on by people who may have less background and intelligence than our technical staff planners. Simplicity of concept and method therefore may be important. It happens sometimes that a highly complex technical plan is a mental triumph but an operational failure.

Planning and the Scientific Method

It is evident that planning is mental work. It involves the application of a logic of effective thinking to the solution of some problem. The success of the organization depends on the success with which the planning function is performed at every organizational level. Executives in the lower echelons contribute chiefly to the development of short-range project plans. Most of their time is spent usually with problems having to

do with the control of whatever operations are under their command. Executives in the higher echelons may spend most of their time in the development of long-range administrative plans, policies, and programs.

The importance of the planning function warrants a brief look at the basis of the mental processes that are involved. Figure 3.2 attempts to show the general nature of these processes. Intelligence is a basic factor in effective thinking. It may be defined as the basic mental capacity for problem-solving thought. Intelligence tests are often used, with other devices, in the selection of executive trainees for this reason. Personality is an important factor in gaining acceptance of one's ideas. Mental ability is a resultant of intelligence and personality plus training. Knowledge

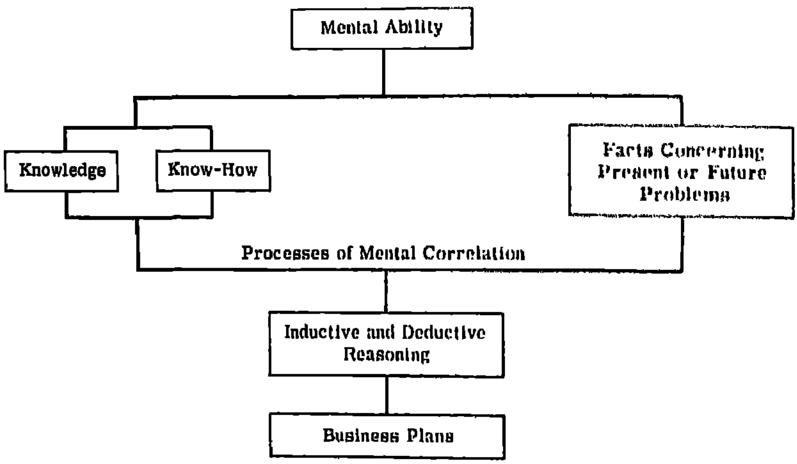


Fig. 3.2. The Basis of the Planning Function. Mental Ability Intelligence + Training + Personality

and know-how are two important factors in the process, in consequence. The term "knowledge" refers to some basic body of principles, points of view, general methods of attack, and other background information bearing on the solution of certain general classes of problems. The term "know-how" refers to the body of facts and skills that one acquires from practical experience in solving specific difficulties within some general class and type of problems. Know-how cannot usually be gained from books. It must be acquired on the job. It enables a person to get the job done, provided that the job falls within the range of previous experience. Knowledge gives the person mental breadth and adaptability. It enables him to undertake the solution of new problems that are beyond the range of previous experience. A person who has good intelligence

and knowledge may be a good theorist. A person who has good intelligence and know-how may be a good mechanic. A good professional man possesses some optimum combination of both.

Problem-solving thought involves some process of mental correlation. It combines the knowledge and know-how that we have acquired in the past with facts concerning present difficulties to develop solutions of present or future problems. It involves inductive reasoning from facts leading to possible solutions of the problem. These solutions should be analyzed to determine their probable consequences. They should be tested to determine the extent to which they meet the requirements of a satisfactory solution. This requires deductive reasoning from whatever generalizations are the basis of the proposed solution. It is evident, then, that effective thinking rests on certain principles of logic and psychology. The purpose of the process in business is a plan that will accomplish the designated objectives with satisfactory economy and effectiveness.

The term "scientific method" may refer to any orderly method that seeks to apply the logic of effective thinking to the solution of some type of problem. It is not some mysterious, highly mathematical technique that is peculiar to the exact sciences. It does not depend necessarily on the use of complicated methods and expensive gadgets. Scientific management is merely the application of the scientific method to the solution of business problems. No profession has a property right in the scientific method. It may be used by anyone who has the necessary intelligence, training, background, and practical experience, including self-educated graduates of the school of hard knocks. It is a common heritage of our civilization.

Various analyses of the principal steps in the scientific method have been made. The following analysis has been helpful to this writer:

1. Recognition of the problem, and the general determination of the principal difficulties that are involved.
2. Preliminary observation and analysis of the situation, including the determination of the limiting factors in the problem.
3. The development of tentative solutions.
4. The testing of proposed solutions.
5. The development of the best practicable solution.
6. The final testing of the solution.
7. Intelligent compromise.
8. The installation and activation of the agreed plan.

Nothing will be done about a problem until someone recognizes its existence. Nothing may be done then until some competent person has the courage to take appropriate action. Many executives watch for subordinate employees who make intelligent suggestions and show some

evidences of initiative. They may have mental alertness and other abilities that qualify them eventually for executive leadership. Recognition of a business problem depends often on the observation of certain difficulties in the operation of the business. These difficulties represent failures to achieve satisfactorily whatever objectives have been designated previously for accomplishment. We shall assume that the particular objectives have been selected properly. These failures, then, must be due either to poor leadership somewhere, unsatisfactory business relations of some kind, unsound policies, malperformance of functions, poor selection or provision of the human and physical factors that are required, or poor handling of some other factor. The purpose of the preliminary investigation is to determine the factors that are limiting our ability to get results and to get whatever facts are necessary for an evaluation of them. The business difficulties that are encountered in the course of interviews, examinations of records, observations of conditions, and other investigational activities suggest usually the factors concerning which we need more facts. We may not get too much help from current research. One cannot forecast, usually, what new knowledge, if any, will be contributed by a research project, or when. Current research therefore is more likely to contribute new facts for future planning.

The evaluation of the factors, forces, effects, and relationships in the situation usually results in ideas concerning possible solutions of the problem. The term "hypothesis" means merely a logical explanation that provides a tentative solution. The principle of multiple hypotheses is applied frequently in business, when the importance of the problem and the available time permit. This principle says that the best solution is more likely to be found if two or more possible solutions have first been set up tentatively. A policy that requires a staff department or committee to consider at least two possible solutions for a major problem has a number of advantages: It gives greater assurance that all the possibilities in the situation will be considered. It may reduce friction resulting from a tendency of some executives to defend vigorously their pet solutions. Some insurance against our inability to forecast business accurately is provided if alternative plans are prepared in skeleton.

No plan is anything but theory until it has been tested and proved. We can apply the pragmatic test of results, of course, by putting the plan into effect generally. A failure may be very costly, however. It is more practical usually to deduce the probable consequences of each plan; to compare these consequences with standards or criteria of satisfactory results; to check the results of our reasoning by limited tests that simulate actual

conditions under which the plan must operate. Product plans are tested, using mock-ups, pilot models, and prototypes. The proposed product is tested in laboratories and proving grounds. The operations or steps required to make the product, and its component parts, are tested. Pilot lines may be set up. Limited production may be undertaken in a pilot plant. Customer and dealer acceptance may be tested in a limited area. The weaknesses and strengths of the new design are observed and recorded. Complaints are evaluated. It is likely to be the case that each plan has its strengths and weaknesses. The best practicable plan may be some combination of the best features of the various tentative solutions that have been tried out. The final solution is just another solution, however, until it has been checked out also. The economy and effectiveness with which a plan operates is limited by the degree of understanding and acceptance that it receives. Intelligent compromise in working out the final solution is desirable. It requires only a modification or choice of method, without sacrifice of proper objectives or sound principles, to accommodate the beliefs or desires of organization groups or individuals. A sacrifice of sound objectives and principles to expediency is appeasement. It is immoral, unsound, and leads to failure. The final step is, of course, the installation and activation of the plan. It is the point where we begin to leave the field of planning and enter the field of organizing. It is the area in which line and staff frequently must coöperate closely. Plans for primary operations must be taken over eventually by our line organizations, and operated.

Organizing

The function of organizing is the work of creating in advance the basic conditions that are a prerequisite for a successful execution of a particular plan. It is regarded generally as an organic management function: its contribution is vital to the successful accomplishment of any mission. There are a number of reasons why this is the case. The conditions underlying effective, economical operations are or should be set up in our plans. Superior competitive effectiveness is not possible until these conditions have been provided. An attempt to provide them while we are commencing the execution of product and process plans may create serious difficulties. It may cause, for example, loss of time in achieving the planned level of production, insufficient labor and equipment utilization, underabsorption of overhead expense, failures in meeting shipping schedules, and many other difficulties. They may spell serious financial losses and a dangerous deterioration of our competitive position. This

applies to any business. Large manufacturing organizations frequently spend millions of dollars for the work of organizing before they have made or sold a dime's worth of new product. The money goes for organizational studies, training, changes in plant layout, new equipment, initial inventories of materials, and initial tooling. Much of it is spent by our sales division for advertising and other marketing activities having to do with the introduction of the new product. Our financial division has an important job of initial financing. These expenditures involve great business risk. On the other hand, a perfect plan might limp along to a dismal failure in the absence of a satisfactory job of organizing. Good coöperation between our line and staff groups in the installation and activation of plans is very important for this reason. We shall look later at the bases for such coöperation.

Controlling

The functions of planning, organizing, controlling, and executing tend to overlap each other, as shown in Fig. 3.3. We can not commence the work of organizing until the planning for the initial phases of the under-

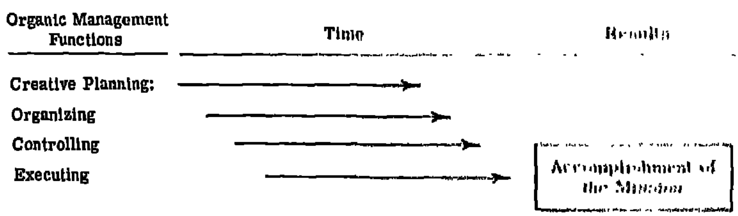


Fig. 3.3. Basic Lead Time in Managerial Performance

taking have been brought to final completion. Control involves much more than a comparison of actual with planned performance and an evaluation of results. The control of a situation should be established before action actually begins. Control that deals only with current action may degenerate into expediency. Control therefore includes any measures to assure that action takes place as planned. It may involve measures to correct deviations of actual from planned results to avoid a failure of the mission. Such activities are necessary, whether we are controlling the execution of a divisional program, or the execution of some operative project. The operations that are necessary to complete an order for a certain quantity of a particular part, may be performed in various departments. It may be necessary to issue instructions to these departments well in advance of the production of the order. Some one must check the

availability of the required material. The order must be scheduled. Its progress must be followed to the end that it will be completed when needed. If an operative employee fails to report for duty or a machine breaks down, some appropriate action must be taken to assure that the order continues to progress on schedule. Many other examples could be given.

The control problem of a large industrial enterprise is complicated. We have administrative controls and operative controls. We have sales, production, and financial controls. Each division, group, department, section, branch, or unit within the organization has a responsibility for a satisfactory control of its operations. An effective discharge of this responsibility is vital to an economical and effective accomplishment of the mission. Control is regarded also as an organic function of management for this reason.

The work of control, wherever we find it, has to do primarily with the constraint, regulation, coördination, and adjustment of activities to meet the requirements of a plan. Constraints should be set up in advance to hold action to the planned course, as far as possible. The rate of performance of related activities should be regulated to assure coördination and the accomplishment of time objectives. Activities must be adjusted to overcome the inevitable interferences with performance. The effectiveness of control, as well as execution, therefore, depends on the quality of the work of planning and organizing that has been done previously. We shall analyze later the basis of control.

Factors in Operative Performance

Execution requires the performance of operative functions. These are functions whose performance results directly and immediately in the creation of required utilities in salable goods or organizational services. This creation of utilities enables our products to satisfy certain needs or desires of the customer, the organization or its members. These satisfactions are values.

The attributes of the product that give it the required utility are its quality attributes. The performance of primary operative functions therefore, tend to result immediately and directly in the creation of potential customer values. Machine operators in a shop or salespersons in a store perform such functions. They are usually called "line" operatives for this reason. The clerks in the office of a store or a factory are "staff operatives." They perform secondary operative functions. They are secondary in incidence of service to the public, but not necessarily in importance. The

values that result from staff work are needed by the organization for the accomplishment of its mission, or are wanted by the people who compose it. They therefore serve the accomplishment of secondary or collateral objectives. Operative employees, whether line or staff, perform "making" functions. Their work involves no responsibility for the direction and supervision of others. They work under the leadership of an executive employee to whom they report.

An effective, economical performance of functions, either managerial or operative, requires more than competent people. Such performance requires, in addition, money machines, materials, methods, other physical facilities, and proper organizational relationships. It is the responsibility of ownership, working through its appointed executive leadership, to provide such implementation. It is the contribution of capital to increased *per capita* production. An increasing standard of living above the subsistence level depends largely but not entirely, on increasing effectivity in capital application. We shall see this when we look later at some modern high-production equipment. We have various staff agencies that assist in the provision and use of physical performance factors. Organizational economy and effectiveness depend, also, on the greater labor effectivity that results: better selection, assignment, training, motivation through incentives, morale development and maintenance, and other work of good leadership by management. The personnel department is the principal staff agency that assists the line organization in the proper handling and utilization of people.

It is evident that the basic factors in the performance of functions fall into two general categories: physical factors and human factors. Their characteristics and requirements are determined ultimately by the requirements of functions for the accomplishment of objectives.

Standards and Standardization

A standard may be defined as that which is established by authority, custom, or general consent as a model, criterion, or rule of measurement. Business standards are criteria that enable us to proportion and relate functions, physical factors, and personnel to business objectives by means of policy. Standardizing is merely the work of developing and applying such criteria.

Management at various organizational levels deals with all the basic factors, forces, and effects in a business situation. Executives must select, proportion, and relate them properly when developing a plan for the

accomplishment of a designated objective. They must see, when organizing subsequently, that the basic factors and conditions required for execution are present in the right relation to one another, before action begins. They must control the use of these factors and forces through executive and operative subordinates. They must check results against objectives. Any effective, economical performance of managerial or operative functions requires the use of appropriate and adequate standards.

Most classifications of standards have to do with physical factors and forces. They have been developed for the most part by scientists and engineers. A managerial classification of standards must be broader. The following classification is intended to meet this broader need:

A Managerial Classification of Standards

1. Standards of service
2. Standards of policy and function
3. Physical standards
4. Personnel standards
5. Performance standards

Standards of service include criteria of the end values of the particular goods or services that we supply to the public. It therefore includes specifications of their component parts or elements. The work of standardization starts with the development of service standards. This is because the primary objective of the business organization is an economic service for our customers. A satisfactory accomplishment of objectives depends on a proper performance of the work of creating the required values. It follows that standards of policy and function are necessary. Many concerns have organization manuals. They specify what is regarded as sound organization structure for the company. Effective accomplishment depends also on the use of correct methods for performing assigned functions and duties. Many concerns also have standard practice manuals for this reason. Work cannot be effective, however, unless it is related to objectives by means of sound principles and accompanying rules governing their application. Functions are related to objectives by means of policy in other words. We may find policy manuals, in various forms, at every level of the organization. They deal with principles governing effective group relations. An employees' rule book is a common form of policy manual at the operative level. Policy manuals deal at the top administrative level with organizational relations within our company, relations with our customers, suppliers, dealers, or any other business relations. Any manual dealing with any function or factor may have the force and

effect of a technical order. Such orders authorize the use of conditions, methods, and relationships. They do not authorize action.

Work is performed in a factory by machines and men. The term "physical standards" refers to criteria of any physical factors, forces, and conditions that are necessary for the performance of a particular kind and type of work. They enable us to plan and provide these factors in kind and quantity for best results. We have standards of illumination. They enable us to provide good working conditions, in so far as lighting is a factor. We standardize equipment, tools, and in fact all physical factors in so far as practicable. People are usually more important in accomplishing results than things. It is obvious, however, that we cannot standardize people. The customer decides ultimately, through his patronage, what work shall be done. The requirements of this work determine what people and things must be used. We can and should set up standards that people must meet to qualify for a particular job. The personnel department, for example, has files of job specifications. It may apply various personnel tests and standards in an effort to select the right man for the right job.

A plan is no better than its execution, so far as results are concerned. We may have, in a large organization, thousands of employees performing hundreds of different jobs in many different locations. Some of these people are in the shop. Some are in the office. Some are out on the road, selling our goods. We must have some standards that will enable us to measure the results that they are accomplishing and to coordinate their activities with one another. Such standards are usually called performance standards. They are necessary for control purposes. They enter also into the performance of other managerial and operative functions.

If standards are so important in business management who determines them? That depends on the nature of the business, the size of the organization, the point of view of top management, and many other factors. In general, they are determined provisionally by the staff group that makes the greatest use of them and has the specialized ability to do so. The recommended standard is subject usually to concurrence by other organizations that are affected, and to approval by higher authority. A time-study standard, for example, is usually determined in the shop by a time-study department. The introduction of the standard is subject, in some concerns, to acceptance by the head of the department that must apply it. It may be protested by an employee representative when it is felt to be unfair.

Responsibility, Authority, and Accountability

The term "responsibility" usually refers to the obligation that an individual assumes when he accepts a general work assignment, or job. It is the obligation of the individual to perform properly the functions and duties that have been assigned to him, to the best of his ability, in accordance with the directions of the executive to whom he is accountable. It includes, obviously, the obligation to perform properly any specific work assignments that may be given to him. Responsibility is an obligation that is created by the contractual process of employment. There is an express or implied acceptance of this obligation when one accepts any position, whether executive or operative, with any business organization. It is evident that business responsibilities are derivatives of business functions. The latter are derivatives of business objectives, as we have seen.

There are many reasons why responsibility is an individual rather than a group phenomenon. Individual responsibilities lose their identity when they are fused with other individual responsibilities in a group activity. It is difficult to determine who is accountable if the group fails to accomplish its mission. It is difficult to take prompt and just disciplinary action, either positive or negative, when it is required. The morale of the group and its effectiveness probably will deteriorate as a result. Other undesirable developments may take place. This is one of a number of reasons why only advisory rights of decision are delegated to committees, in most cases. There is such a thing as group attitudes, of course. This is a related but different problem. It will be considered later in connection with morale.

There are two general classes of employees in any business organization. They are executives and operatives. There are accordingly two general kinds of responsibility; managerial and operative. The first is a leadership responsibility within the business organization. The second involves no significant or formal responsibility for the direction and supervision of others. It is merely the responsibility of the operative employee for the proper performance of assigned operative functions and duties, under executive direction.

The division of responsibility within an organization rests primarily on functional grouping and definition. It is the work of determining assignable units of responsibility with reference to certain organizational and procedural elements. Its general objective is adequate, clear-cut specifications of work obligations for the various executives and operatives composing the organization. These obligations may be specified in terms of

criteria of a proper performance of functions, limits of activities, and general results expected. Responsibility can be distinguished, therefore, from the work content of the particular job.

The importance of a sound determination and division of responsibility is indicated by its objectives. The following are some of them: (1) specification and activation of the division of labor and the basis of specialization, (2) more effective and intelligent coöperation, (3) reduction of executive work load, (4) greater managerial effectiveness, (5) increased organizational speed of accomplishment, (6) economy in executive overhead, (7) less friction and better morale within the organization, and (8) a sound basis for the division and delegation of authority. Functional grouping and definition is necessary, but it can supply only part of the basis for accomplishing a mission. We are not likely to get the most results of a satisfactory quality at least cost until we can establish accountability. This means that we must be able to place responsibility definitely on individuals. We must then measure the results of their discharge of this responsibility against standards that are fair to customers, owners, and the organization, as well as to the individual. One hears occasionally a complaint that the individual is not getting satisfactory coöperation from associates or subordinates. This is not necessarily a problem of attitudes. It may be that many organization members do not know exactly where their responsibilities begin and end. They may not understand clearly what work they are to perform personally, what work should be done in coöperation with others as designated, what work must be done under the specific or general direction of one's immediate superior. They may not know when, where, and how one should coördinate one's activities with others. These and many similar questions may arise from a failure to divide, define, and delegate responsibility properly. It is obvious also that the division of leadership responsibility can affect greatly the work load of an executive. There is a principle of functional homogeneity. It says that organizational effectiveness is increased and the cost of executive and operative labor is reduced when duties are grouped in accordance with functional similarities. Similar problems develop from the performance of similar functions. Decision making is an important part of an executive's job. Fewer, different decisions are necessary when the groups under an executive's command are performing functions that are basically similar. It is not necessary to make decisions as frequently. The members of a group are able to coördinate and coöperate with one another directly when they are dealing with similar problems. Costs are reduced by making homogeneous assignments of

responsibility, because an employee usually expects to be paid at the rate for the highest grade of service that he is required to perform. A nonhomogeneous executive assignment may set up a job requirement for a background, training, and experience that is unnecessarily broad. It creates artificially a scarcity of executives who can handle the assignment successfully. It tends to reduce the size of the group which can be directed and supervised. It therefore increases the number of executives who must be maintained on the payroll. A good division and definition of responsibility, based on a logical grouping of functions, enables an organization to proceed quickly and confidently in the accomplishment of its mission. The organization is more likely to know what it is doing, in addition to other advantages that have been noted above. Homogeneous work assignments and good delegations of responsibility tend to develop in the employee a proprietary interest in his job. Good leadership, good coöperation, and good coördination also tend to develop good morale. A reduction in job pressures should give the executive more time to sit back and think.

Organization Structure and the Division of Responsibility

An individual may perform a step in the completion of a project. It may, for example, be an operation on an order of parts for one of our products. He may then do a different operation on a different part. He gets in 8 hours of time, in the course of the day, on various projects that fall within his general work assignment. He is responsible for completing each of these job assignments in reasonable conformity with reasonable standards of quantity, quality, time, and expense. The requirements of competitive customer service make it necessary. This operative reports with others in his group to a supervisor. This supervisor with others in a departmental group, reports to a higher operative executive. It is evident that there is a relation between business objectives, functions, responsibility, and the elements of an organization structure. The relations between the following functional concepts will bring it out:

Ultimate Unit of Function: A single simple act of operative performance, either mental or physical, that has definite points of starting and stopping. The unit motion is an important and practical concept in motion and time study.

Elementary Operation: A combination and grouping of unit functions that constitute a distinct phase or division of a step in the completion of an operative project. This is also an important concept in motion and time study.

Operation or Procedural Step: A combination or grouping of elementary

operations that constitutes a distinct sequential division of the work of accomplishing a project.

Project: Any specific undertaking that has definite final objectives. The completion of the order of parts was the project in the preceding illustration.

Specific Operative Work Assignment: An operative project, or a phase of one, that is given to an operative employee for performance. It involves no significant responsibility for the direction and supervision of others.

General Work Assignment: The specification of the general functions and duties to be performed by an individual in doing certain kinds of work on certain kinds of operations and projects that are normally assigned to him. It is the individual's job.

Ultimate Unit of Responsibility: The obligation of an operative employee for the proper performance of the work assignments that constitute his job.

Unit of Operative Supervision: The number of units of operative responsibility that are suitable for face-to-face leadership and supervision by a minor supervisory executive. It is the ultimate unit of executive responsibility. It is represented by the job of the "lead man," "group leader," "assistant foreman," "supervisor," "unit chief," or similar operative executive.

Unit of Executive Supervision: The number of subordinate units of executive responsibility that are suitable for administration by a higher executive.

We shall see shortly that an organization structure is some structure of suitable units of operative and executive supervision. The requirements for economy and effectiveness in operations determine ultimately what is suitable.

Units of Supervision and the Span of Control

There has been much discussion in recent years concerning what span of control is best for maximum managerial effectiveness. This term merely means the optimum number of subordinates that should be assigned to a particular executive for direction and supervision.[1] There is no formula for determining what is the correct span in a given executive situation. The theory in back of the concept is still in the process of development. Our present information concerning spans of control is based chiefly on surveys of current practice. It has given us some knowledge of the limits within which such spans tend currently to fall. These limits are useful in formulating judgments concerning effective spans. Obviously, they are not substitutes for judgment.

A distinction has been made above between operative units and executive units of supervision.[2] An optimum unit of operative supervision is the number of operative employees who can be supervised personally

[1] Direction, supervision, and corrective action are subfunctions of control.

[2] Most writers apply the term "span of control" to the concept of an executive unit of supervision. The term is applicable to both types of managerial units, and will be so used here.

by a minor supervisory executive with maximum economy and effectiveness. The range of such units for most concerns extends probably from a minimum of 10 operatives to a maximum of 30. The range can be exceeded in either direction under appropriate conditions, of course. A unit of professional research workers, for example, may include fewer than 10 operatives. The unit may exceed 30 somewhat when the work of the group is routine, repetitive, unskilled, standardized, and manual. The decisions and directions of the supervisor are likely to be few and simple in the latter case. The size of the unit of operative supervision is affected greatly by the requirements for effective face-to-face leadership.

An optimum unit of executive supervision is the number of subordinate executives who can be supervised personally by a superior executive with maximum economy and effectiveness. The range of such units appears to extend from 3 to 8 or 9. There are some instances in which a president may have only one subordinate, an executive vice-president, who reports directly to him, in addition to a private secretary. The concept of "span" in such a case should be applied to the executive vice-president, rather than the president. There are instances, at the other end, in which an executive may have 12 or 15 subordinates reporting to him. There are some obvious dangers in a span of executive control that is too great. The principal executive may lose control of his situation. A heavy executive work load may cause him to delegate too much responsibility and authority. Excessive delegation becomes abdication. He may bottleneck his organization, on the other hand, if he does not delegate extensively. His subordinates may have difficulty in getting appointments with him to discuss their problems. Other problems may develop. There are a great many factors that may affect the size of the unit of executive supervision. The rate of growth of the business, for example, may require the use of relatively short spans. Good staff work makes it practicable to use longer spans. An executive organization that is well trained and indoctrinated with the company's management philosophy also does not require so much personal supervision. A longer span can be used when functions have been grouped in units of responsibility in accordance with the principle of functional similarity. Good morale obviously reduces the need for personal supervision. There are many other factors that may tend to increase or decrease the span of executive supervision.

Supervisory spans have a marked effect on executive expense, as well as on executive effectiveness. Other things being equal, the expense of minor operative executives can be reduced by increasing the average size of our

units of operative supervision. The payroll for administrative and major operative executives can be reduced by increasing the average size of our span of executive supervision. This reduces also the number of major echelons in the organization, bringing top management closer to the rank and file. The real objective in designing units of supervision is greater executive effectiveness. The payroll cost of top leadership is usually a small percentage of the total payroll in most companies, despite a few large individual salaries. A saving in executive payroll expense can be a bad loss if it impairs the effectiveness of executive leadership.

Authority

Responsibility was defined above as an obligation of the individual to perform assigned duties to the best of his ability under the direction of the executive to whom he reports. Authority is the corresponding right that enables the individual to discharge the particular obligation. Authority is accordingly a derivative of responsibility. The work of the organization tends to divide horizontally into managerial and operative functions. Responsibility and authority therefore can be divided on the same basis. Managerial authority is the right to exercise executive leadership. It is the right, in consequence, to plan, organize, and control the activities of the organization for which the executive is responsible. It consists principally of the rights of decision and command for this reason. Operative authority is the right of the operative employee to perform assigned duties without undue interference so long as he accomplishes the required results in accordance with directions. It is the right of operative decision within whatever limits are established by his supervisor. Operative authority carries with it no rights of decision or command with respect to the work of others. The authority of any member of an organization, whether executive or operative, must be exercised within the limits established by higher authority.

A poor division and delegation of authority can produce many of the organizational difficulties that have been noted previously, but for different reasons. Responsibility and authority are directly related but different things. Failure to exercise initiative, for example, may be the result of a lack of knowledge of one's responsibility for an initiation of action in a given situation. It is not necessarily the result of a lack of mental or moral courage. It may also be the result of hesitation. One may hesitate to act when he does not know whether he has the right to make the necessary decisions; whether these decisions should have the concurrence of some other executives who are not specified; whether one has the

right to issue necessary orders and instructions. It has been the writer's observation that most concerns do a better job of specifying responsibility than they do of specifying authority. The result may be jealousy, poor coördination, lack of initiative, organizational politics, empire building, poor morale, and many other organizational difficulties.

Authority and the Democratic Process

The democratic process is a political process whereby a democratic society governs itself. Temporal power is vested in the citizen under this form of government. It is exercised by him through his elected representatives in his government. No other form of organization can be democratic in its internal operations, including the organization of governmental agencies. Many people confuse applications of the principle of participation, the use of committees, "junior boards," and other organizational devices with the democratic process. The confusion aids those who would like to change the economic and political organization of our society from one of free enterprise, free markets, free competition, and governmental decentralism to one of state capitalism, socialism, and governmental centralism.

The authority of the business executive, in a democratic society, is derived from the right of private property. The term "property" may refer to any disposable goods, lands, or services in which one owns a beneficial interest. The right of private property is the right to hold and use such resources for personal benefit, but with due regard for the public benefit. The public interest is paramount under our theory of government. The right of private property carries with it obviously the right to decide what property shall be held and how it shall be used. Such use cannot be accomplished without the right of authoritative direction. This is the right of command. The authority of the business executive is received, accordingly, from the owners of the business by delegation. This authority may be delegated directly in the case of an individual proprietorship or partnership, or indirectly through a board of directors in the case of a corporation. The executive may delegate his authority in turn, unless prevented from doing so by direction of higher authority. The operative authority of an employee to perform some operative function of the business is received by delegation from some executive to whom he is accountable.

The definition of the right of private property implies the existence of a corresponding obligation. This is the obligation of ownership, operating through management, to provide the public with more goods of better quality at lower prices together with improved service. It is, in other

words, the obligation to contribute continuously to an increasing standard of living within our society. The individual citizen can modify his right of private property by political action through his elected representatives. In so doing, he may vote himself into socialism and vote away his liberties, in some degree, without realizing it. It has happened in some countries. Business leadership recognizes the existence of this danger. This is the political reason why the primary objective of the business organization is customer service. The economic reason is even more obvious: the notion of a profit objective becomes academic in the absence of the customer's dollar.

It should be noted in passing that the employees' right to bargain, either individually or collectively, depends also on the right of private property. One cannot bargain for the sale of personal services in which one has no disposable interest. With the loss of the institution of private capitalism, come state capitalism, socialism, and "directed labor." It follows that employers who stop a legitimate exercise of the right of collective bargaining tend to break down the right of private property in capital, on which a free enterprise economy rests. No property right, either in capital or labor, carries with it any right to exercise force, whether economic, political, or physical, to compel acceptance of one's proposals. It used to be, at least, that duress was one of the conditions that vitiated a contract.

Accountability

Accountability is a requirement or condition under which each member of the organization renders a report on his discharge of his responsibilities, and is judged fairly on the basis of his record of accomplishments. The objectives of the group and those of the individual, together with his duties, responsibilities, and authorities, should be specified by organizational and operational directives. They establish the basis for accountability. The maintenance of accountability is an objective of control. It is the control function of management that determines the degree of agreement between actual and planned performance. Control indicates also the required disciplinary action, if any.

Accountability, like responsibility, is an individual rather than a group problem. We are not likely to get maximum results from the average individual until we can establish fair performance standards and hold him accountable for reasonable performance in accordance with them. The principle of single accountability expresses this idea: Individual account-

ability for results to a single superior executive contributes greatly to the successful accomplishment of organizational objectives.

Delegation and Decentralization

Delegation and decentralization are important managerial processes for reasons that have been noted above. Their performance may affect greatly the success of the business. Some comment on them is therefore desirable before we look at the work of a manufacturing enterprise.

A delegate is a person who is appointed to represent and act for another. Any subordinate, whether executive or operative, is in a sense a delegate of the superior executive to whom he reports directly. The process of delegation is one whereby certain of the executive's functions, responsibilities, and authorities are released and committed to designated, subordinate positions. The direction of delegation is always downward. Responsibility and authority are attributes of the job. Delegation takes place with respect to the job. The appointment of an individual to the job, and his acceptance of the obligations that go with it, entitle him to use the corresponding authority for the duration of his appointment only.

An order may be any delegation of responsibility and authority for the performance of a function. Technical orders authorize the use of specified methods and standards under specified conditions. They are related directly to technical instructions. Technical orders and instructions are combined frequently for this reason. Technical orders do not authorize action. Operational orders do. The process of delegating, then, has to do largely with the release of orders and instructions to subordinates on lower echelons of the organization. We shall see later that this is an important phase of the control function that is called "dispatching." Organizational directives that establish the objectives, duties, responsibilities, and authorities of the various positions or jobs in the company are the result of organizational planning. The work of making the required organizational changes is a part of the function of organizing. The release of organizational directives and orders, putting them into effect, is a part of the dispatching function in administrative control.

Anything more than an elementary discussion of delegation is beyond the scope of this book. There are two principles, however, that should be noted because of their importance. One of them, the principle of the fixation of responsibility, says: The process of delegation relieves the responsible executive of none of his responsibility, authority, or accountability. Delegation is an extension of powers. It cannot properly result

in abdication. There is a principle also of the coincidence of responsibility and authority. It says that the delegation of responsibility should be accompanied by a commensurate delegation of authority. A competent executive will accept responsibility, but only to the extent that he has the right to make the decisions and issue the orders on which a discharge of his obligation depends. A violation of this principle results usually in some breakdown of morale.

Decentralization takes place when some higher central source of responsibility and authority assigns certain functions and duties to subordinate positions. It is accomplished through delegation. Decentralization therefore may be operative, managerial, or both, since functions also may be classified on this basis. The complete decentralization of operative functions without any managerial decentralization would result necessarily in the complete centralization of control in the hands of top executive leadership. This is a condition that would be impractical and undesirable in any except very small concerns. Complete decentralization of all operative and managerial functions, responsibilities, and authorities is abdication. There are an infinite number of degrees and conditions of decentralization between these extremes. There is no one that is best in all business situations.

There are many advantages of decentralization with organization growth. It is desirable to get the point of decision and order giving as close to the point of action as possible. It is necessary to decentralize as the organization gets bigger and more complicated. Controls accordingly, are likely to be centralized highly in the small concern. We may be able to get better coördination of action with less staff expense. Managerial decentralization facilitates the development of initiative self-reliance, and leadership ability. It is impossible to develop a person into a good executive when he never has any opportunity to make any decisions governing the actions of others. There are many other advantages and disadvantages both of centralization and decentralization. Discussions of them will be found in books on top management. It may be helpful, however, to summarize the principal rules governing decentralization:

1. The degree of decentralization that is effective and economical tends to vary directly with:
   a. The size of the organization and the complexity of its functionalization.
   b. The physical dispersion of the organization's activities.
   c. The availability of competent trained personnel in adequate numbers.
   d. The extent to which the decentralized personnel have been indoctrinated with sound managerial and operative philosophies.
   e. The extent to which organizational morale is high.

f. The quality of organizational planning for future growth.
g. The quality of subordinate leadership, particularly at decentralized operative levels.

2. The degree of decentralization that is effective and economical tends to vary inversely with:
a. The speed, accuracy, and capacity of available communications, equipment, and services.
b. The degree of standardization of the factors and conditions in the company's operations that can be developed and maintained.
c. The degree and extent of emergency that must be handled.
d. The degree of organizational instability and personnel turnover.

Functional Analysis

It is evident that an executive should have something more than a casual knowledge of the work of the organization that is under his command. His success and advancement may depend very much on the economy and effectiveness with which this work is accomplished. It is not surprising, therefore, that management has developed a number of methods for functional analysis. These methods may include any analytical process that has to do with the investigation, collection, and classification of facts concerning some or all phases of the work of an organization. The following are the principal methods in use at present:

A. Organizational analysis
   1. Job analysis
   2. Time and duty study
B. Procedural analysis
   1. Process or methods analysis
   2. Motion and time study

Job analysis is a technique for investigating general work assignments, or jobs. It collects and classifies information concerning their general characteristics and requirements. We shall see later that it is used commonly by top management staff departments, personnel departments, and departmental executives in solving certain organizational or personnel problems. Time-and-duty study is an outgrowth of job analysis. It emphasizes the time factor in a general work assignment. It seeks to discover what is necessary to increase the proportion of time that is spent on directly productive work, and reduce the proportion that is spent on indirectly productive work. These methods study group activities, even though they may collect information from individuals within the group.

Procedural analysis investigates project activities. Process analysis studies the general requirements for the effective economical operation of

a procedure. It usually traces the steps or stages through which a kind of project passes as it progresses toward completion. This technique is used commonly in work simplification by the industrial engineering department, the office manager's department, and by the department heads immediately in charge of the work. Motion-and-time study is an extension of process analysis into the individual steps in a procedure. We may have a clerk in the office who is entering figures on some routine report form from a record which he keeps. We may have a drill-press operator in the shop who is drilling a hole of a specified diameter in a specified location in a part. This operation may be one of the steps in making the part. Motion-and-time study seeks the facts concerning the same basic question in both cases: What is required to enable the operative employee to do more work of the same or better quality, with the same or less effort? The methods analyst gets these facts by breaking down the work of the operative employee into its elements for study and analysis. We shall see how this is done when we look at the work of the time-study department. It should be noted that we also teach elementary motion study principles to supervisors and department heads. They have the immediate responsibility for the economy and effectiveness of the operations under their command.

Further discussion of these methods for functional analysis must be postponed until we come to the departments that make the greatest use of them. It is necessary only to recognize, at this point, the basic importance of business functions in business operations, and the general nature of the techniques that are available for their study.

PROBLEMS

1. The *Wall Street Journal* of May 5, 1956 reported the results of a survey. It showed that company presidents regard the development of a top management team as one of their most important responsibilities. It further reported that such executive teams in most companies consisted of a small number of executives. They include, usually, a production chief, a sales manager, a financial officer, and a presidential staff assistant, in addition to the president. Other positions were rarely represented on this executive group.
   (a) What is the relation of the above situation to the distinction of certain functions as organic functions of business?
   (b) What is the basis for distinguishing organic functions, and of what value is such classification?
2. A company which had grown from an organization of 15 employees to one of 375 in a period of 10 years. A considerable number of managerial problems had developed as the organization grew. Typical of such difficulties was the operation of the tool crib. Employees had followed the practice of securing

their own tools and returning them after use. Many such tools were never returned and many were returned in unusable condition. There was no way of knowing who had returned such tools. Their worn or broken condition was not known frequently until they were again required. Another typical situation was the manner in which purchases were made. A salesman was often able to effect a sale by contacting line supervisors directly, with the result that separate orders for the same items were being processed for different departments.

(a) What principles of organization were violated? Is the situation described above a natural development?

(b) How would you go about correcting the conditions described? What are the limiting factors in this situation?

. A small independent radio station is beginning to experience organization difficulties because of its rapid growth. At the present time it has fewer than 25 full-time employees. The general administrative functions are performed by a manager. Certain functions have been completely differentiated, and are headed by supervisors who report directly to the manager. There are two program supervisors. One of them plans all the educational programs and edits the scripts, secures talent in coöperation with the production supervisor, etc. The other program supervisor plans all the other programs, approves all program scripts or plans, and is expected to study the effectiveness of all the station's programs. He schedules all the programs, the use of the studios, etc., in coöperation with the production supervisor. The production supervisor prepares continuities for all the programs; he assigns, announces, and directs all the programs; selects talent in coöperation with other divisions, holds auditions, etc. One of his subordinates is also responsible for the station's publicity work, but reports directly to the station manager on this phase of his work. The operating supervisor is responsible for the operation of all the equipment used in broadcasting, its maintenance, the recording of all programs, the installation of new equipment, etc.

(a) What would you say are the organic functions of a radio station?

(b) Assuming that you are correct, what general development in organization structure would you expect in this case?

CHAPTER 4 •

• Organization and Morale

Organization, Organization Structure, and the Function of Organizing

AN executive is paid largely for his ability to engage in problem-solving thought concerning managerial difficulties. Sound decisions depend on the ability to formulate accurately the concepts on which effective thinking rests. This requires some knowledge of the factors, forces, and effects in the particular problem. An understanding of them depends on accurate, clear-cut, concise definition of words that describe them. The problem of getting a meeting of minds in committee meetings, for example, is sometimes a problem in semantics.

There are a number of terms in the literature of management that may mean different things to different people in connection with the same problem at the same time. The terms "organization," "organization structure," and "organizing" are among them. There is a popular definition, for example, that says that "organization is people." An organization is certainly composed of people. A mob of people may be something less than a poor organization, however. We shall define a good organization, therefore, as any group of people, large or small, which has been implemented adequately and is coöperating willingly under the direction of competent executive leadership in an effective, economical accomplishment of certain common objectives. The emphasis is on the human factor. We cannot neglect organizational functions and the physical factors in the problem, nevertheless.

Organization structure is merely the structure of relationships between similar functions, physical factors, and personnel that is set up for the accomplishment of the mission. Its purpose is to promote coöperation and facilitate an effective exercise of executive leadership. Hence it is an instrument of command. Organizational directives, organization charts, and job specifications are some of the instruments that spell out the nature

and significances of these relationships. They facilitate the delegation of responsibility and authority, the development of unity of command and single accountability. They aid in accomplishing other objectives of good functional grouping, delegation, and decentralization that have been noted previously. The design of organization structure is accordingly one of the important problems in organizational planning. An executive may be able to get a limited amount of staff assistance, in a few large organizations, in planning and developing his organization. He is still responsible for the development of his organization, and its operation, whether or not he makes use of such staff. Reliance on staff cannot relieve an executive of this or any other responsibility. This can be done only by action of higher authority. It is therefore desirable that we look briefly at some of the basic organizational concepts underlying the design of organization structure and the control of operations.

The function of organizing has been defined as the work of creating, in advance of execution, the basic conditions that are a prerequisite for the planned achievement of designated objectives. These conditions should be prescribed by the plan itself, or by supporting plans. Organizing includes the provision of information concerning functional groupings and relationships that have been determined previously by organizational planning. It includes, of course, information concerning the required physical factors and conditions. The organizational directives, organization charts, and job specifications that were mentioned above may have the status of technical orders. They may authorize and require the use of specified methods, conditions, and relationships. They do not authorize the actual work and expense of developing the specified organizational conditions and relationships. Authorization of action is the function of an operational order. The work of organizing for the production and sale of a new model of product, for example, is a major project in itself. We shall see that it breaks down into many subprojects. Many departments of the business must spend much time, money, and effort before we can go into quantity production. It may be necessary for a large concern to invest a large fortune before it is able to sell a dollar's worth of goods. It is necessary, consequently, to control the work of organizing. This control is accomplished partly through the timed release of appropriate operational orders.[1]

We have noted above that organizing involves things and physical conditions, as well as people. Capital implementation is necessary usually

[1] We shall see when we look at the field of accounting and finance that these are chiefly expense and asset orders.

to enable people to accomplish more than minimum results. So financial men, accountants, engineers, purchasing agents, and other specialists have been busy, following the completion of each phase of planning. Some of their work must be completed long before we begin to bring in any large number of operatives. Financial arrangements for financing the cost of organizing presumably have been completed. There must be some control of the large expenditures that are being made. The purchasing department must procure in the initial inventories of materials. It may buy some new equipment, in coöperation with production, engineering, and maintenance departments. The tool manufacturing division is busy making the initial tooling, except as we buy part of it. The maintenance department probably will set up the required equipment, both new and old, in accordance with plant layout plans of the industrial engineering department. But these plans had to be based on the organizational plans of our top management staff. Many other projects, involving primarily the provision of physical factors and conditions, must be accomplished. All such projects must be completed in accordance with an approved program and schedule for organizing. Otherwise the initiation of production and distribution of the new product will not begin as scheduled. We shall incur a competitive disadvantage accordingly.

There are many manufacturing problems in which the function of organizing is vitally important. The problem noted above, the production and distribution of new product, is just one of them. *Organizing* is necessary when we expand into new territory. It is necessary when business growth necessitates the development of multiplant operations. We may have serious organizational problems when the need for product diversification results in the acquisition of old concerns that have gone to seed. Organizing is an important function when we develop economic integration either horizontal or vertical. It is necessary when we must adjust our operations to rapid technological improvements in product or process. It must be considered when we make major developments of management methods. It is often a vital function when we must expand rapidly to handle defense production. It is necessary when a great many other situations develop. A thorough discussion of organizing is beyond the scope of this book, however. It should be realized, nevertheless, that the function of organizing is universal. We must plan and organize whenever a significant change in business objectives, policies, and functions is anticipated. This is one reason why planning and organizing are regarded as organic management functions.

Forms of Organization Structure

There may be an infinite number of variations in the structural forms of different businesses. These forms, for the most part, are merely stages or special cases in the problem of differentiating and grouping functions. They develop with increases in volume and complexity of the particular business. There are only two basic forms of organization structure, nevertheless. These are (1) line organization and (2) staff organization. The structure of a particular organization is some combination and development of them in some degree. Books on management, including this one, refer to "functional" or "completely functionalized" organization. This is not a basic structural form, however. It is, rather, a certain relationship between line and staff responsibility and authority.

The Line Organization

Line organization is the primary form of organization. It is the hierarchy or chain of functions, people, responsibility, and authority that leads directly to the creation or distribution of primary values. A line organization develops because of some necessity for a greater division of labor and specialization in the creation or distribution of salable goods or services. The necessity is the result usually of successful competition and growth. The primary functional hierarchy is the chain of functions that leads from ownership to primary operative performance. The corresponding chain of people is the line organization. The chain of responsibility and authority that corresponds with these functions and people is the primary chain of command. The downward development of any functional hierarchy, whether primary or secondary, is known as functional devolution.

Stages of Line Devolution

The development of the line organization goes through certain stages. Certain managerial problems tend to be associated with certain stages. Recognition of these stages, knowledge of their characteristics, and an understanding of the problems that are frequently associated with them is helpful, obviously, in analyzing managerial difficulties. A thorough discussion of managerial diagnostics also is beyond the scope of this book. We shall therefore confine ourselves to a brief discussion of the following stages:

1. A complete integration of ownership, managerial, and operative functions.

2. The initial differentiation of ownership and managerial functions from operative functions.
3. The initial differentiation of the organic business functions.
4. The initial formation of line organization elements.
5. The development of major and minor echelons with continuing line devolution.
6. A highly developed line specialization, based on an extensive division of primary operative labor.

These stages cannot be distinguished so sharply as has been done above. They tend to shade into one another.

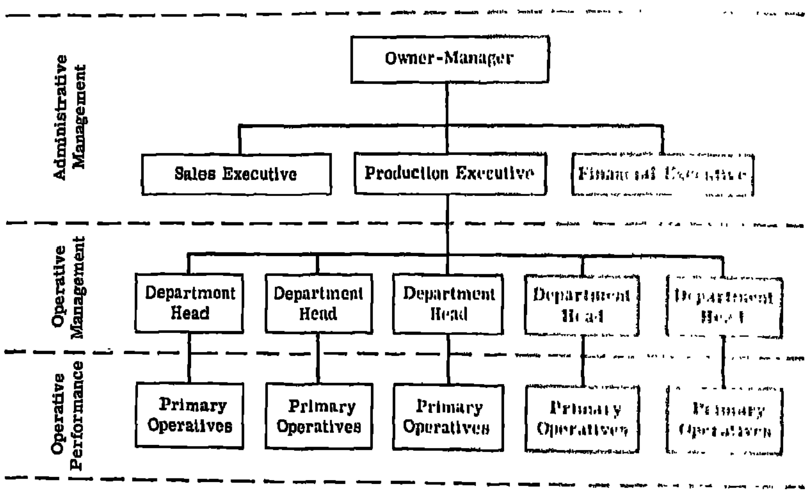


Fig. 4.1. A Line Organization

A chart of a simple line organization is shown in Fig. 4.1. It has developed beyond stage 1, evidently. It could have started there. There is a manufacturer of home cleaning fluids and compounds who started in business, literally, by mixing his products in his bathtub. He has a small manufacturing plant today. There are cases of men who have started with a single store and have built a chain-store organization. Other examples could be given.[2] It is evident that in stage 1 all the ownership, managerial, and operative functions of the business must be integrated completely. There is only one man, the owner. He must provide or secure the necessary money for his business. He must plan, organize, and control his activities. He must produce and distribute the goods or services with which he serves

[2] It has been suggested that such American success stories belong in the past. This is obviously untrue, since there have been many cases in which it has happened after World War II. Individual success in private enterprise is less probable, of course, with a continuing trend toward socialism.

his customers. The owner has certain personal objectives in starting his business. He hopes to make a profit, in addition to the equivalent of whatever wages he could earn by working for someone else. He wants, probably, certain intangible values in addition. They may be greater independence, greater satisfaction of certain creative urges, or some others. They are collateral to the primary objectives of his business, as we have seen. The accomplishment of any objectives can be described in terms of quantity, quality, time, and expense. There are many independent craftsmen who do a quality job, but the customer cannot count on their delivery promises. They may lose money when they think they are making it, because of inadequate accounting records. There are other reasons why they remain very small businessmen.

We shall assume that a small manufacturer has succeeded and grown from an individual proprietorship. There must have been a day when he hired his first helper. He entered stage 2 when he did. That was the day when he began to differentiate his ownership and managerial functions from his operative functions, and probably without realizing it. He created a leadership responsibility for himself. It did not amount to much initially. It is probable that he delegated only the unskilled work to his helper, keeping the managerial and skilled operative functions for himself. Good common sense probably told him that the latter functions play a more important part in the success of his business. No doubt our manufacturer found it necessary, before long, to hire a salesman to help him handle the increasing sales and develop more. This salesman also was an operative employee. The owner-manager made a distinction between his producing and selling functions, as well as his managerial and operative functions, when he put this salesman on the payroll. The organic functions of a manufacturing business began to emerge. The development of the line organization had entered stage 3. The devolution of these functions would result later in the development of the line divisions of the organization, including their supporting staff groups.[3] Various leadership and organizational problems can develop during this stage that may inhibit further growth of the business, or actually cause its failure.

There are limits to the number of subordinate operatives who can be supervised effectively by a single superior. The reasons will be noted shortly. It is necessary with continued growth to form organization groups, based on groupings of similar operative functions. Supervisory executives,

[3] Every major business field has its organic business functions, as noted previously. So every individual proprietorship will go through this and subsequent stages of line development, if it continues to grow.

who can be held accountable for results, must be placed in charge of each group. These supervisors or foremen report directly to the owner-manager. It is evident that he has introduced a managerial echelon between himself and his operative employees. He has begun the transition from a relation of direct, or face-to-face, leadership of his men to one of indirect leadership through executive subordinates. The devolution of the line organization has entered stage 4 certainly. The increasing separation of top leadership from operative followership, with further line growth, may develop some serious problems of coördination and morale maintenance. This process of devolution will continue with business growth. Further divisions of labor and specialization will become necessary. New groupings of primary operative functions will be made, probably by further differentiation of old groupings. Definite organizational echelons, or service levels, will begin to appear because of the effects of specialization and the limitations of practicable spans of supervision. The structure of the line organization may now look something like that shown in Fig. 4.1. Its development has entered stage 5. Many significances may be attached to it. One of the most important is the distinct differentiation of administrative management from operative management that has begun. This marks the beginning, therefore, of decentralized operations. The owner-manager must devote more and more time to long-range problems involving group management. He has less time for short-range problems having to do with the completion of specific customer orders or other operative projects. More of his time is spent on the work of planning and organizing, and less on the work of controlling primary operations. This may be a critical stage in the growth and development of the company. The owner-manager may not recognize the necessity for increasing decentralization. He may not be able to delegate and decentralize functions and responsibilities, if he does. He may not be competent in other ways to perform as an administrative executive.

The final result of continued line devolution is stage 6: highly developed line specialization, based on an extensive division of primary operative labor. Certain problems may become accute in this stage. It is probable that they have been developing during the previous stages, but without any adequate recognition of them by line leadership. These problems may include the selection of bases for the grouping of primary operative functions, the study and design of operative and executive units of supervision, the development of effective supervisory leadership, and the breakdown of simple line coördination. We might, in fact, add a final

stage in line devolution; the eventual breakdown and failure, with continuing growth, of simple line organization unsupported by staff. We seldom see this stage or condition, because the growth of the organization is stopped by its structural inadequacies, or the force of circumstances compels us to develop staff.

The Grouping of Primary Operative Functions

The development of organization structure is an effect of an increasing volume of business. Organizational problems are a part of the penalty for business success. The increasing work load makes necessary an increasing division of labor. It makes possible and requires the development of increasing specialization. Some line operative specialization may begin with stage 2, the initial differentiation of ownership and managerial functions from operative functions. It does not usually become a major factor in the development of line organization structure until our line divisions have developed departments. It may become very important when these line departments begin to develop subgroups or supervisory units.

These subdepartmental groupings of line functions should be made on some logical basis. It will be seen in Fig. 4.2 that there are at least 4 bases for grouping primary operative functions. These are:

1. Product or service
2. Physical or geographical dispersion of activities
3. Process or method
4. Some dominant physical factor in performance.

We shall see that product is the basis for setting up departments in many large mass-production industries. We set up production lines in automobile plants, for example, for pistons, crankshafts, or some other component part. One or more production lines may be the responsibility of a department foreman. He may have assistant foremen, group leaders, and line operatives under his command. Our sales division may use principally a geographical basis. It has regional and district sales offices possibly. It may use also a supplementary product or commodity basis. A chemical process usually breaks down into certain distinct stages. They set up corresponding requirements for managerial and operative knowledge and know-how. A chemical plant may departmentize by grouping its primary operative functions on the basis of the principal steps in the process. The manufacture of metal products to customer specification on a job order basis usually requires the use of general-purpose machine tools. Line production departments in such a plant may be organized,

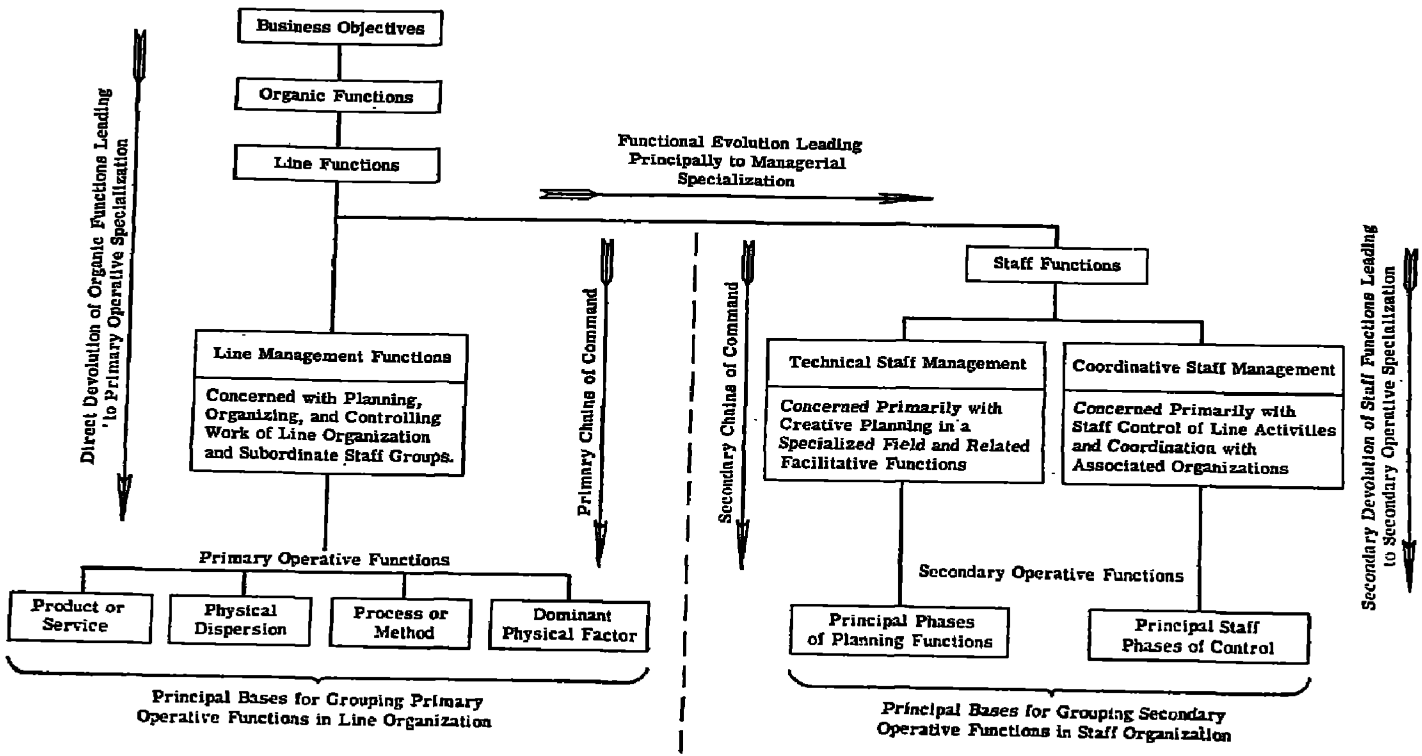


Fig. 4.2. Basic Business Functions and Functional Relationships

accordingly, on the basis of the different mechanical functions performed by different types of machine tools. These tools are the dominant physical factors in performance in this case. The general basis of grouping line operative functions then is a satisfaction of the requirements for handling effectively some physical factor, force, or condition that dominates the performance of the particular primary operative functions. Each of the bases of grouping, noted above, involves a general functional similarity for this reason.

Organization Structure and the Span of Control

The line organization in Fig. 4.1 shows 5 line department heads. They report directly to the production executive. Is this the right number? Perhaps the total number of operatives should be regrouped in 4, 6, or more departments. How many primary operatives should report directly to a supervisor? Perhaps the operatives in certain or all departments should be regrouped under a number of supervisors.

These questions are important, because the answers will greatly affect executive payroll costs, the effectiveness of executive leadership, or both. They have led to the development of the span of control concept in organizational planning. This concept merely says that there is a limited number of subordinates to whom an executive can give an effective, face-to-face leadership. The problem breaks down into two parts, however: the number of operatives who can be supervised directly by a supervisory executive, and the number of subordinate executives who can be supervised directly by a superior executive. The first is known as the unit or span of operative supervision. The second is known as the unit or span of executive supervision. Some studies of spans of supervisory control have been made in recent years.[4] They tend to confirm earlier observations, indicating that the basic problem is probably the natural limitations of executive capacity for face-to-face leadership.

The unit of operative supervision tends to be larger than the unit of executive supervision. The size range appears to be from 10 to 30 operatives, approximately. The decisions of the supervisory executive tend to be routine and repetitive. They have to do largely with the supervisory control of operative work. They involve a minimum of futurity, since they are concerned largely with the execution of current projects. The size of the unit is closer to the lower limit when:

[4] See Ernest Dale, *Planning and Developing the Company Organization*, AMA, 1952, p. 51; and James Healey, "Span of Control and The Coordinating and Control Media Used by Ohio Manufacturing Executives." (A doctoral dissertation, University of Pennsylvania, 1952.)

1. There is considerable labor turnover within the supervisor's group.
2. Methods and conditions of work are changing continuously.
3. Considerable on-the-job training by the supervisor is necessary.
4. The supervisory unit is a group of professional operatives. It may approximate the upper range of the span of executive supervision. The work of such operatives is largely mental. It has to do frequently with operative phases of planning and research. It may be necessary for the supervisor of a professional group to spend quite a bit of time with each of his men.
5. The organization is set up to handle emergency situations where close personal control is necessary.
6. The morale of the organization is low.

The unit of operative supervision tends to approach the upper limit of the size range, and may exceed it, when the work of the operative is entirely manual, routine, and repetitive. The frequency and amount of time required for supervisory contacts with operatives are minimum. Operatives find it difficult, on the other hand, to contact their supervisor for advice and assistance when his unit is too large. The supervisor may lose control of his situation, causing a breakdown of discipline and productivity within the group. We have too many supervisors on the payroll, however, when the unit is too small. There is no formula for the solution of the problem. It is a matter of observation and judgment. The size range, indicated above, is merely a helpful guide.

The unit of executive supervision appears to range from 3 to 8 or 9. It is smaller than the unit of operative supervision for a number of reasons. The work of the executive tends to be mental, rather than manual. The decisions that the superior executive must make are not usually routine and repetitive. The higher one goes in the organization, the more this tends to be true. These decisions have to do with problems of objectives, policies, and plans for the particular organization, and with the work of organizing for the execution of future programs. They involve the coördination of thought chiefly, except when they deal with interferences with current operations that constitute a major emergency. The decisions have to do frequently with broad, basic problems of the group. They are less tangible than current problems of execution. They deal with the future which can never be foreseen with a high degree of accuracy. Such decisions may be difficult to make, for these reasons.

The length of the span of executive supervision also may have some important effects on the economy and effectiveness of the organization. If the span is too long, the responsible executive may bottleneck his organization. Subordinate executives may have difficulty in getting an appointment with him. Their work may be held up in consequence while they wait for

a conference, a policy interpretation, or a decision. Otherwise, they must go ahead without proper authorization, hoping that their action will be approved subsequently. The responsible executive may be forced to delegate more responsibility and authority than he should, to overcome this situation. There is the danger that he may lose control of his situation if delegation is carried too far. It is obvious that the pressure on a superior executive tends to increase as the breadth of his responsibilities and the number of his subordinate executives are increased. He has a greater load of personal direction and supervision. The tensions under which the modern executive works are due in part to such difficulties. If the span of executive supervision is too short, however, we may have too many high-priced top executives. The chief executive may be too far removed from the operative levels of the organization. Other difficulties develop. A longer span is practicable when the responsible executive is supported by good staff planning and coördination. He can have more subordinate executives reporting to him when they are able men who have been thoroughly indoctrinated with his managerial philosophy. A longer span is practicable also when similar functions have been grouped in homogeneous assignments of responsibility. It is practicable, too, when few major decisions are required, and executive conferences are not too frequent or of long duration. A shorter span is indicated usually when there is a continuing danger of emergency situations in which the responsible executive must take personal command. A growth industry or one subject to rapid technological change also may require a shorter span. Low morale in an organization may have much the same effect. These and other practical considerations must be balanced against one another in determining what is a practicable span of executive supervision.

Organizational Service Levels

The levels concept in organization recognizes the existence of echelons or levels of service within the organization. All the functions performed by a business organization should be necessary, or they should be discontinued. They are necessary presumably because the values that they create are needed, directly or indirectly, for the accomplishment of our primary service objectives.

The contributions of each function are not of equal value, however. The least valuable function is that of common labor, usually. It may require chiefly physical strength and stamina, with a minimum of education and training. The most valuable function is, or should be, the work

of top leadership. There may be a great many gradations of functional contribution between these extremes. It is obvious that there may be different jobs in different chains of command that have approximately the same functional worth. They should have approximately the same base pay rate, if that is the case.

Any organizational planning must take into account the existing and developing service levels within the organization, and the resulting classes and grades of service. The initial development of echelons, or service levels, for a simple line organization was shown in Fig. 4.1. This organization is small. It would have approximately 100 operatives, if the unit of operative supervision were 20 men. The initial differentiation of operative and administrative management can be seen. The levels of operative service are not evident. The existence of major operative levels has been indicated in Fig. 3.1. We shall see certain minor levels when we look briefly at the problem of job evaluation.

The major echelons in an organization are the broad levels of service, such as top administrative management, supervisory management, skilled labor, and others. The minor service levels are distinct classes or grades of service within these major echelons. It requires only a small number of major echelons to command a large number of men.[5]

Simple Line Organization Structure and Organization Size

A simple line organization is not found usually, except in very small organizations. It is the dominant structural form in any small concern, for some very good reasons. Staff means overhead expense. The competitive strength of the small concern may be due to a minimum of expense. It is practicable, as well as economical, to the extent that the principal executive can direct and supervise operations personally, without killing himself. A simple line structure is easily understood. The simple, direct lines of authority facilitate self-coördination and voluntary coöperation. Morale may be quite good, despite the fact that working conditions and wages are merely average. This is due frequently to the close personal contacts between the boss and the rank and file of the organization. The organization is quite flexible usually because there is a minimum of specialization. Short chains of command also make possible quick decisions. The organization and its activities can be adjusted quickly to changing conditions, with a minimum loss of effectiveness for these reasons. Some

[5] Henri Fayol, *General and Industrial Management*, Pitman Publishing Corporation, 1949, p. 55.

recent surveys have indicated that the growth of large business organizations has not diminished the number of small organizations. One reason may be that a simple line structure gives a competitive advantage, when the small company is largely a service organization.

The simple line organization has its disadvantages, of course. It provides for a minimum of operative specialization and no managerial specialization. Many of the above advantages enable the small company to succeed initially. They become disadvantages with success. The ability of the small organization to succeed depends largely on the technical and managerial ability of its chief executive. When the business outgrows the boss, the simple line organization is in trouble.

The line remains the backbone of the organization, nevertheless, despite the fact that continued business growth requires the development of highly professional staff groups. The line devolves from the organic functions of a manufacturing business: production, distribution, and finance. It ends in primary operative specialization. The line organizations of a company are those that produce or distribute salable values. The business organization exists, under the free enterprise system, by reason of the customer's dollar. Staff must serve line for this very excellent reason.

Staff Organization

A staff function is one that has been differentiated from a line hierarchy of functions, at some level, to render some service to the line organization. This service presumably has become necessary to enable the line organization to accomplish its mission. A staff organization is merely a group of qualified people who are rendering this service, under the leadership of a staff executive. The work of these people has been organized presumably on some basis that will permit this service to be provided economically and effectively. The staff executive is responsible accordingly for the provision of such service.

The evolution of staff from line is shown schematically in Fig. 4.2. It is evident that the executive head of every primary staff organization must report to some higher line executive. The staff executive and his organization do nothing, basically, that the higher line executive would not have to do for himself, if he had no staff. It therefore follows that a staff organization is primarily the result of a differentiation and separation of certain managerial functions from the line organization. The purpose of staff evolution and development is a division of managerial labor, and the provision of specialization in the performance of certain managerial func-

tions. The mission of staff management is therefore the effectuation of line leadership in the accomplishment of the primary objectives of the business organization.

Basic Staff Functions

Since management is a universal organizational function, it follows that increasing staff evolution with organization growth is a universal phenomenon. Any study of growth organizations will show that it is. It is the mission of the business organization to supply the public with certain goods and services in the required quantity and quality at a price that the latter is willing to pay. This means, in a competitive economy, that the organization must perform its functions, both line and staff, economically and effectively. It is the mission of staff to assist line in accomplishing the primary objectives of the business organization. It is evident, then, that the basic objectives of staff organization are the secondary objectives of the business organization—economy and effectiveness. This means, of course, that staff objectives are secondary in order of service to the public; not necessarily in importance. The values that are produced by a staff organization are used, directly or indirectly, by a line organization in the creation or distribution of customer values.

The specific duties of any organization are determined by its assigned objectives. The objectives of the personnel department, the engineering department, the purchasing department, the legal department and other staff departments differ from one another. So do their duties. It is evident, however, that there must be some basic staff functions. The characteristics of each function and the amount of work required for its performance vary with the type and kind of staff organization. These basic staff functions are:

1. Investigation, including research
2. Analysis of facts and information
3. Interpretation, including services of information
4. Recommendation, including the formulation of plans
5. Coördination, including assistance in control
6. Facilitation, including assistance in organizing and executing

Staff Responsibility and Authority

Responsibility and authority are derivatives of objectives, policies, and functions. The preceding discussion therefore raises the question of staff responsibility and authority. The staff executive is responsible for proper performance of all basic management functions, but only so far as the work of his staff department or division is concerned. His authority includes

rights of both decision and command with respect to the work of his subordinates, within the limits of delegation by his superior. The staff executive usually has only advisory rights of decision outside of the limits of his organization. His is a leadership of ideas, rather than of command, in so far as the organization as a whole is concerned. Any orders that are issued from his office, whether technical or operational, usually require the concurrence of other line and staff executives who must execute them and the approval of higher line authority. This can be accomplished without excessive red tape, paper work, delay, and unnecessary burden on executives by means of organizational and policy directives, standard office procedures, and other means. Conflicts between line and staff executives may develop if clear-cut, sound relations between line and staff responsibilities and authority are not maintained.

Functional Organization

There are exceptions to the above statements occasionally. They occur usually when it is necessary to place a highly specialized, technical function in direct contact with the line functions that are served, delegating certain rights of decision and command to a technical staff executive, within very narrow technical limits. This act of endowing a technical staff responsibility with line authority sets up what has been called a "completely functionalized" relationship. It is done, for example, in some situations involving staff quality control. The result would be a "functional organization" if it were done generally for all staff organizations. It is not done generally because it violates certain principles of good organization.

Stages in Staff Evolution

The development and growth of staff organizations tend to go through certain typical stages. They are an effect of the universal necessity for staff evolution with organizational growth. Various management problems tend to be associated with each of these stages. An understanding of the principal stages in staff development is therefore helpful in diagnosing managerial difficulties. The following are the principal stages:

1. Line integration
2. Distinct staff differentiation
3. Complete staff differentiation
4. Staff integration
5. Staff elevation

6. Staff decentralization
7. Complete staff separation.

It has been noted previously that staff is an evolution from line organization. It takes place at the level in the organization where the needed service can be most effective. It follows that the seeds of future staff development are found in the simple line organization of the small business organization. We find executives in small organizations doing work that would be done for them by staff subordinates in a large organization in their field. It is frequently difficult to recognize the existence of these potential staff functions, because we are in stage 1, in which they are completely integrated with primary line functions. We enter stage 2, when it becomes necessary to separate certain operative phases of a staff function from the managerial work of a line executive, because of an excessive work load. It may be that these operative details are being handled poorly, or not at all, to the detriment of the business. They are assigned to a subordinate to be performed under direction. He becomes in effect, if not in title, a staff assistant to the line executive. The subordinate's work load probably will grow with continued organization growth. He will require assistance eventually. It will be necessary at some point to recognize the existence of a new staff unit; to grant minor staff executive status and authority to its head. We have entered stage 3. The organization chart of a materials or supply division is shown in Fig. 19.1. It may be that previously finished stores and shipping had been under the sales organization. Purchasing had been a separate department. Each product division of the manufacturing division had its own separate storeroom, and so on. It may become necessary, with further growth, to bring together in a larger staff organization all independent staff units and departments that are performing similar staff functions within a general staff field. This has been done apparently in the case illustrated in Fig. 6.1. This development may have been forced by supply failures, a breakdown of coördination between supply functions, or some other difficulty that indicated the desirability of integrating the principal supply functions under a strong, able leadership. We have entered stage 4 in the development of this staff function, whatever the reason.

The ills of organizational size and maturity may weaken our competitive ability and stop our growth. It is possible to overcome these difficulties, however. We shall assume that we continue our growth, to the point where multiplant operation is desirable. We shall pass from stage 4 into stage 5 as we go from one to two or more plants. The various staff

groups in the original plant should have been performing certain staff duties of administrative management. They must have been performing certain staff duties of operative management. It will become necessary probably to begin the development of headquarters staff groups in the general offices of the company before we open the second plant. These groups will assist the top general executives in the administration of inter-plant operations. They will take over and expand certain staff administrative functions that were performed by corresponding groups in the original plant. It is evident that there has been an elevation of these functions to a higher echelon. It is probable also that some executives in the original staff groups will be promoted to headquarters staff jobs. There should not be many. These headquarters staff departments are small, provided that decentralization has been accomplished properly.

Decentralization within the individual plants will become necessary also with continued growth. We shall look later at the function of production control. A single small production control department may be sufficient in a small plant. Growth in the plant's volume of production may make it necessary to set up staff control units in subordinate line divisions or departments of the manufacturing organization. The staff function of production control has obviously entered stage 6.

A staff function is separated completely from the line organizations of the company in stage 7. It is set up in an independent, autonomous position in the corporate organization. It is subject only to a very broad administrative control by corporate headquarters. This stage can be reached only by a few highly specialized staff functions in very large corporations. The independent and separate educational facilities, research corporations, and buying organizations of some large concerns are examples.

Functional Emergence and Staff Development

It is difficult to recognize when staff functions should emerge as distinct, separate activities, and when certain staff activities should progress from one evolutionary stage to the next. The illogical, cumbersome, and sometimes ineffective structures of some organizations are the result. There is no formula for the solution of the problem. The decision is a matter of judgment. There is a principle of functional emergence that may serve as a guide: The tendency of a given function toward differentiation and independent grouping increases with (1) the degree of dissimilarity between the particular function and other

work with which it is grouped; (2) the growth in the volume of work required for the performance of the function; (3) the tendency of the function to become increasingly technical with growth.

It is a difficult problem to determine what man power is required after a staff function has been differentiated and granted an independent existence. The function probably will continue to grow with the growth of the organization. The problem is important because staff expense is "overhead." Job analysis and time-and-duty study, together with practical experience, permit an estimate of time absorption by various staff activities. There are various methods for administrative work measurement of staff activities that show man-power utilization. Ratio analysis of line and staff personnel strength and expense can be made. These and other techniques make it possible to estimate man-power requirements with reasonable accuracy.

This still leaves the problem of correct structural relationships, both internal and external, for the new or expanding staff group. This is a problem in organizational planning. There are in addition many problems of selecting and developing people for staff duties.

Basic Classification of Staff Functions

It has been noted previously that staff development provides needed managerial specialization and a division of the load of managerial work. A basic classification of staff functions must rest, accordingly, on the classification of basic management functions; creative planning, organizing, and controlling the work of the organization for which the executive is responsible. The basic staff functions are therefore:

Technical Staff Functions: Those whose purpose is primarily to assist line executives and their organizations in performing the function of creative planning, or to supply some service of technical facilitation. Such functions require some specialized background, training, and experience for their performance. They are not necessarily engineering or other professional functions, however. Executives in charge of staff planning organizations have a staff responsibility for coördinating thought between line and staff in the solution of problems within the particular staff field. They do not coördinate the action required for the execution of plans.

Coördinative Staff Functions: Those whose purpose is primarily to assist executives and their organizations in performing the function of control, or to perform some facilitative function that is associated closely with the coördination of action. Such functions require for their per-

formance a broad background, training, and experience, rather than one that is narrow and highly specialized.

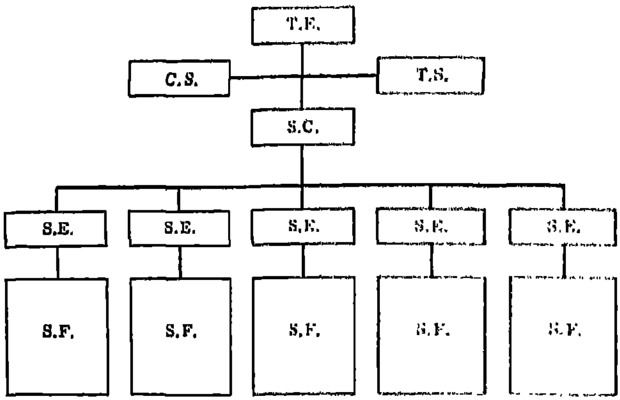
The general relations of these staff functions to line functions has been illustrated in Fig. 4.2. A temporary task force, whose membership is drawn from existing line and staff groups within the company, may be set up to organize a new division, plant, or region. There is usually no permanent, separate, and distinct staff group for organizing, however. This does not change the fact, nevertheless, that organizing is a basic management function. Line and staff should coöperate in the accomplishment of this work. We shall assume that a plan of some kind has been developed by one or more technical staff groups within the organization. It has been accepted by the line organization that must operate it. These technical staff groups then assist the line organization in setting up the conditions that are necessary for the operation of the plan. Routine coördination of the work of organizing should be accomplished by some control group. Otherwise some higher line executive must coördinate this work, which is expensive. The line organization should take over at some point and begin to operate the plan. There is no need, in consequence, for a permanent staff function that specializes primarily in organizing. A department of organizational planning, for example, does not specialize in organizing. It specializes in a certain kind of planning. Its proposals are subject usually to concurrence by the organization that is served and to approval by higher line authority, like any other technical staff group.

Basic Organization Structure

It has been seen that there are some definite stages in line devolution and staff evolution through which functions tend to go. There are basic management functions. There are basic differences between managerial and operative functions. There are other reasons why the differentiation and grouping of functions with business growth tend to follow a basic organizational form. An understanding of this form is helpful sometimes in analyzing organizational problems. It should be remembered, however, that there is no mathematical or formulistic substitute for good executive judgment.

This basic organizational form has been illustrated in Fig. 4.3. The various line and staff functions do not emerge and develop at the same time and rate. All functions of the one-man organization are integrated necessarily in the person of the owner-manager-operative. The line functions tend to emerge first, as the business grows. Various staff func-

tions evolve later, in the order of need for a division and specialization of managerial labor, or for some service of facilitation. The number of subordinate executives who may report to a superior executive is not limited to five. This was noted during the discussion of the effective span of executive supervision. A business organization cannot be compared safely with the basic organizational form unless these and other limitations are borne in mind.



Legend:

T.E.: Principal executive leadership
S.C.: Second in Command, if the size of the operation warrants. He may have whatever rank and title is appropriate, from assistant department head to executive vice-president.
T.S.: Technical staff groups.
C.S.: Coordinative staff groups.
S.E.: Subordinate line executives. They are primary line executives, if it is a line organization; secondary line executives, if it is a staff organization.
S.F.: Subordinate functions under their command.

Fig. 4.3. Basic Organizational Form

Let us assume that the one-man organization, mentioned above, has grown through the past 20 years into a multiplant operation. Its basic top administrative organization would probably fit into the basic organizational form as follows: the top executive is the president; the second in command is the executive vice-president. Their duties will be examined briefly when we look at the industrial organization. The technical staff and coördinative staff functions may be represented by a top administrative staff group. This group assists top management in its work of planning, organizing, and controlling the activities of the corporation as a whole. The subordinate executives are line vice-presidents and staff directors who report to the executive vice-president. The line vice-presidents head up the organic divisions of the business. They are in charge of sales, production, and finance, since this is a manufacturing business. There may be

two or more staff directors or vice-presidents. They head up the major staff divisions that have grown and developed at least into stage 5 of staff evolution. These executives might be, for example, the director of purchases and supply, the director of personnel and industrial relations, the director of engineering and research, the comptroller, or certain other administrative staff executives. It will be seen that these major staff divisions represent major technical staff functions.

Some directly productive departments within one of the plants may grow to considerable size. The organization structure of a shop department also tends to develop in accordance with basic organizational form as its size increases.

The same thing is true for the staff departments and divisions. They present some interesting problems, since the manner of their development depends on the type of staff function that is being performed. Technical staff departments usually develop before coördinative staff departments. The need for the former is usually felt first. They may be any staff departments performing functions that require the use of specialized techniques or procedures for the solution of certain special problems. The subordinate executives in Fig. 4.3 head groups that specialize in different phases of planning, if the principal mission of the staff department is the development of certain types of plans. An example will be seen in Fig. 9.3, an organization chart for a product design department. The subordinate executives in Fig. 4.3 head groups that specialize in some facilitative service, if the principal mission of the department is some technical service of facilitation. An example will be seen in Fig. 13.1, an organization chart for a plant maintenance department. A large technical staff division frequently develops a need for coördinative and technical staff functions, under its principal executive. They are secondary staff functions, obviously, since they are attached to secondary chains of command.

The production control department of a large plant is an example of a primary coördinative staff department. Such departments supply very important services of coördination and control. They are small, usually, as compared with the organization of a technical staff division. They tend to follow the same basic form, nevertheless. There are certain functions of control that can be assigned to such a staff group, if there is enough work to warrant it. There are certain control functions that can not readily be delegated to staff. They tend to remain in the line. We shall assume that the basic organizational form in Fig. 4.3 represents some control department; that the work of staff control requires a few clerks

for the performance of each distinct subfunction or phase of staff control. The subordinate executives, in such case, head groups that specialize in these staff phases of control. It is likely that there will be no need for a second in command, or for secondary coördinative and technical staff functions. The department head must perform these functions personally in such case.

There are some advantages in the use of a basic organizational form in organizational planning. It may suggest errors of omission or commission in the development of organization structure, including faulty applications of organizational principles. It may indicate, accordingly, the need for further investigation, study, and analysis of the particular organizational problems. There are many organizational problems, however, that cannot be portrayed satisfactorily by this or any other diagram.

Staff Operative Specialization and the Test of Staff Organization

A staff organization develops its own chain of command with growth, as noted above. It is a growth downward, or devolution, from the principal leadership of the staff group. It ends in staff operative specialization, with a corresponding division of staff operative work. This is a secondary specialization, since it results in the creation of values that are needed by the organization or its members, rather than the customer. These staff values have to do basically with greater economy and effectiveness in the accomplishment of the primary objectives of the business organization. The objectives of a staff group are usually determined by higher line authority on the basis of recommendations by the responsible staff executive. These objectives are determined ultimately, however, by the requirements for a successful accomplishment of the primary mission of the company.

It is sometimes difficult to determine by inspection of an organization chart whether a particular organization is line or staff. The determination is important, because it conditions policy decisions concerning specific line and staff relations, delegations of responsibility and authority, and the solution of other organizational problems. The preceding discussion indicates the basis of the determination. It is a line organization if operative specialization in the accomplishment of its objectives results directly and immediately in the creation or distribution of salable values. It is a staff organization if operative specialization results immediately and directly in usable values that facilitate the accomplishment of the organization's primary objectives. An engineering department, engaged in product design, produces plans for a product. The public does not

buy plans. It buys product. An operative in a shop department performs an operation on a component part of the product. The part is made in conformity with the product designs of the engineering department. This part contributes directly and immediately to the ability of the end product to satisfy certain customer needs or desires. It is obvious that the engineering department is a staff organization; that the shop department is line. There are groups in many organizations for which the distinction is not so obvious, however.

Coördination

The term "coördination" has been used frequently during previous discussions. It is used in different ways in industry. Executives coördinate one another for informational purposes. They coördinate their plans with those of other executives. They coördinate the activities of their subordinates personally or through some staff control group. There are various kinds and conditions of coördination. It is necessary to use the term because it is imbedded firmly in the language of business and industry. Some definition of the term is required obviously before it can be used safely.

Coördination means in general, the development and maintenance of a proper relation of activities, either mental or physical. There are, accordingly, two kinds of coördination; the coördination of thought and the coördination of action. The coördination of thought has to do primarily with the relation of mental activities. It depends frequently on the prior development of some common concepts on which effective thinking within the group can rest. Unity of thought concerning fundamental concepts is usually considered to be a prerequisite for a meeting of minds. Coördination of thought therefore is necessary in the joint development of plans by various technical staff groups. It is necessary also for the development of organizational morale, as we shall see later. It is obviously important in policy formulation. The coördination of thought within an organization is accomplished frequently by the staff executive who has the principal responsibility for a solution of the particular problem. It is accomplished sometimes by a technical staff executive who is attached to the office of a higher line executive. It can be accomplished by the line executive personally, but it will be expensive. It should be emphasized again that unity of thought does not mean uniformity of thought. The latter can be fatal to an organization that must operate under competitive conditions.

The coördination of action has to do primarily with the relation of physical activities. It has to do usually with the execution of plans and

programs that have been formulated previously for the accomplishment of some mission. It relates action to the objectives of the mission with respect to time and the correct order of performance, as established by the plan. Reference was made previously to a component part of some product that we are manufacturing. Our production control department has an order to make 250 pieces of this part. It has also an "operation sheet" or "plan of work" for making the part. This plan lists in the correct order the operations or steps that must be performed. It gives also the standard production time required to complete each operation. It supplies other production information, as we shall see. The production order probably states the date when the 250 pieces should be completed. We can work out a detailed schedule for the order, if it is desirable, indicating the date by which the order should be completed on each operation. We shall see how this is done when we look at the problem of production control. It is sufficient at this point to note that we have set up a basis for coördinating the action required for the completion of the production order, with respect to time and order of performance. Similar coördination of action is necessary for an efficient execution of any program or project, either line or staff. It is accomplished often by a coördinative staff group. The term, as used from here on, will refer to the coördination of action, unless otherwise specified.

It is evident that there are a number of methods that can be used to accomplish coördination. The principal methods are (1) personal coördination by the superior executive, (2) coördination by a staff group which acts for the superior executive, and (3) cross-coördination by subordinate personnel. The last method involves direct coördination by personal contacts between subordinates on their own initiative. This happens frequently when coördination of activities is necessary, even though objectives, policies, and general methods are well established. It may happen when an emergency arises, and time is the essence of the problem.

Staff Organization Elements and Executives

The smallest organizational element is the individual. The principal staff organization elements, on this basis, are consultants, independent staff executives who are permanently attached to the organization, staff departments, and committees.

CONSULTANTS

There has been an increasing use of consulting firms by business organizations during the past 10 years. There are firms in every business

and technical field where the solution of problems requires a highly specialized background, training, and experience. Consulting service is an intermittent or temporary staff service, so far as a particular company is concerned. It is limited in time and expense by contract, the pleasure of the client, or the time required for the solution of the particular problem. The service rendered is conditioned and limited by the understanding with the client accordingly. This service may include surveys and investigations of certain problems in the client's firm. It may require analyses and interpretations of the resulting facts, coöperation with the client's executives. It may include assistance in the formulation of plans for the solution of the particular problem. It may be necessary to assist these executives in the subsequent installation of the plan. This assistance may include aid in organizing for the subsequent operation of the plan. The consulting firm may perform other services within its particular field of specialization.

The employment of consulting service cannot relieve top management of the responsibility for the solution of the organization's problems. The consultant sells advice chiefly. This advice may be excellent. It can be no better, however, than the executive who receives it. It is of little value if the particular executive lacks the ability to make constructive and effective use of it. The same thing can be said for any staff service, internal or external. Ability to make effective use of staff is a mark of a competent executive. Use of staff cannot relieve the executive of delegated responsibilities for results, however.

INDEPENDENT STAFF EXECUTIVES

Such titles as assistant to, executive assistant, assistant to the president, consultant, and others of a similar nature are frequently used. Such men are attached permanently to the organization. Their tenure of office is subject to continued satisfactory service, of course, like any other employee. Each may have only a private secretary and a couple of assistants under his personal command, however. They may be highly salaried, nevertheless. These men may perform many of the services that would be rendered by a consultant. They may perform certain functions of facilitation and coördination, with respect to staff departments and divisions, that a consultant could not provide effectively. Such men must be classified as independent staff executives.

STAFF DEPARTMENTS

It has been noted previously that new staff units are formed when we enter stage 3 of the process of staff evolution. This is the stage of a

complete differentiation of certain specialized functions from the parent line organization. These staff units may grow into branches, sections, departments, and staff divisions if such growth is warranted by increases in the volume of business and the need for increased staff service. They may grow anyhow, unless there is a good control of the work load of the staff department and its utilization of man power.

The staff unit, department, or division renders usually a specialized service in a specific functional field. Such staff organizations as the engineering department, the purchasing department, the personnel department, the accounting department, and others are found commonly in industry. The work of the principal staff departments of the industrial organization will be discussed later.

COMMITTEES

The committee is a type of staff organizational element that deserves a brief comment here. The space limitations of this book prevent adequate consideration of committees later in connection with the work of the various line and staff divisions. Committees are common in business and industry. They frequently make many important constructive contributions. They have also some serious shortcomings.

A committee is a group of individuals who meet for the purpose of effecting an integration of ideas, leading to a meeting of minds, concerning a solution for some problem. It may or may not participate directly in developing the solution. Some committees assist a responsible line executive chiefly in the work of creative planning. Some merely facilitate the work of organizing. It is obviously a technical staff type of organization. It is a slow, cumbersome, ineffective, and expensive device for coördinating action. When it is endowed with line authority, trouble may be ahead.

The number and importance of committees tend to increase with the echelon on which they serve and the size of the organization. The reason has been indicated above. They are very effective in the field of administrative planning and policy formulation. The top executives of large organizations devote most of their time to such problems.

Committees may be classified on the basis of the functions that they perform. These functions may be investigational and analytical, educational, legislative, interpretative, or judicial. A fact-finding committee may be set up to investigate a problem, analyze the resulting data, and render a report to higher line authority. The report will probably include the conclusions and recommendations of the committee, but not neces-

sarily. A conference committee may perform functions that are chiefly educational. Its objectives may be a better understanding by certain subordinates of the ideas, plans, policies, and methods of their superiors. A planning committee usually performs a legislative type of function. It assists the superior executive in the formulation of plans and policies. Most committees are integrative in some degree. Temporary committees are sometimes set up for the purpose of accomplishing an integration of ideas and a meeting of minds. There are committees also whose functions are chiefly judicial. Their chief purpose is the interpretation of established plans and policies with a view to determining the propriety of past or proposed actions. Many committees, such as safety committees, suggestion committees, and plant executive committees, perform judicial functions.

Comittee action has some important advantages. They account for its widespread use. It can contribute effectively to unity of thought and action by facilitating the dissemination of information and integration of ideas. It can apply the principle of participation in the development of decisions without relieving executives of individual responsibility for results from the organizations under their command. It cannot do so, however, unless the committee is kept strictly in a staff position. A better understanding and acceptance of plans and policies, together with an integration of individual and group interests, may result in better morale. The quality of the organization's planning may be improved by committee action. It acts as a deterrent to hasty action, because considerable time may be required to develop a joint decision. An ambitious, aggressive executive may find it more difficult to take unilateral action in pushing plans that promote his personal interests, as well as the organization's.[6] Plans and policies may be a result of a cross-fertilization of ideas from the best minds in the organization, if they are on the committee or have been consulted. Rotation of committee membership, overlapping tours of committee service, and the inclusion of some junior executives in committees is helpful in executive development. There are other advantages of committee action.

There are also some serious disadvantages. They are the reasons why

[6] This requires usually an application of the principle of compulsory staff advice: No decision on an important problem should be rendered or action taken by the responsible line executive until all who may be able to contribute significantly to the success of the mission, through advice and assistance, have had an opportunity to do so. Responsible executives may be required by policy and procedure to consult with the appropriate staff agencies before making a final decision on plans or authorizing action. This requirement is subject to the limitations of time and emergency, of course. The right of final decision remains with the executive.

the principal divisions of the business organization are headed by individual executives, rather than committees. They indicate why a committee should be set up in a staff relation to line groups on lower echelons; why it is a poor device for controlling actions.[7] Its recommendations may represent merely a compromise between certain important, strong executives on the committee. An aggressive, dominant executive may be able to drive his proposals through a committee and get its approval of them. It is actually the executive's decision, but he is relieved of the risk of personal responsibility for results. Group decisions are more likely to be influenced by emotionalism, and to be less objective accordingly. Judgments may be influenced by reactions that stem largely from personal interests. Decisions made by a majority vote may get the acceptance of the group, in consequence, but not its whole-hearted support. Some executives do not permit their committees to take a formal vote on proposals for this reason. The executive makes the final decision, guided by the discussions in the minutes of the committee's meetings. The committee's interest in its work may be killed however, unless it is informed of the decision before it is put into effect and has an opportunity to discuss it. A strong line executive may dominate his committees. Their function then may be chiefly to develop the details of the boss's ideas and to accept them. A committee may become merely a group of "yes men" when the line superior resents criticism of his ideas and opposing suggestions. Advancement in the organization may be retarded, for example, if one is unable to appreciate the brilliance of the proposals.[8] There are other reasons why committee consideration of proposals does not necessarily assure the formulation of the best plans and policies.

There are other reasons, in addition to those above, why a committee is seldom used to control action. A committee member may not be available when an emergency requires a quick decision. Service on a committee, charged with control responsibilities, would make demands on an executive's time that are too great. Too much committee service

[7] There is some question as to whether the board of directors can be regarded as an exception to this statement. It is the representative of ownership, in the first place. It is concerned chiefly with the determination of general objectives, policies, and programs for the corporation, and the general evaluation of results. There are other reasons.

[8] It is the writer's experience that such men are the exception, rather than the rule in business. His acquaintance is limited, of course. It must be recognized, furthermore, that some concerns have staff policies and procedures that are based on the principle of staff independence: "The extent to which the responsible line executive receives competent, frank advice and assistance from staff subordinates, depends on their ability to recommend or take necessary staff action without fear that differences of opinion with the superior will jeopardize the subordinates, position or personal interests otherwise."

interferes with one's management of the organization for which one is responsible. The control of operative action often requires quick decisions. Committee action is cumbersome and slow. There is no one who can be held accountable for a failure of the action to accomplish planned results. Responsibility is diffused among the members of the committee. Committee decisions are expensive, furthermore. Their cost is the time of the participating executives at their individual salary rates. There are more economical control devices, as we shall see later.

There are certain measures that should be taken, in addition to those noted above, to get satisfactory results from committee action. The specific measures that are necessary depend on the type of committee and its particular mission. It is composed frequently of executives who are regularly in charge of line or staff departments. Their committee assignment involves a temporary staff service. It interferes with the performance of their regular duties in some degree. The interference may not be substantial, of course, if their operations are big enough to afford a second in command, or require little personal supervision because of their routine, repetitive nature. It is obvious that these executives have little time to interview people, run tests, inspect conditions, examine records, or do other work that often is required for a staff investigation. It is too expensive to provide a committee with its own permanent secretariat, except in very large organizations. Arrangements must be made usually for the assignment of committee projects to the technical staff departments in whose fields they fall. The particular department must render a report of its findings and proposals to the committee. Suggestions or requests for a new product, for example, are often referred to a "product committee" for approval. This project, if accepted, is then referred to the company's engineering division for research, development, and design.

Committee members should receive advance notices of meetings. Some arrangements for the performance of their normal duties may be necessary. These notices should be accompanied by copies of reports or other background information, and an agenda for the meeting. Otherwise we may get a meeting of minds, but not mature thought. Time may be saved if there is some coördination of proposals with committee members before the meeting to determine the principal points of agreement and disagreement. Such matters may be the responsibility of the secretary of the committee. The chairman is an important factor in the success of committee action, of course. He must guide the discussion, without restricting it, to prevent unreasonable digressions from the agenda. He must keep

one or two members from engaging in discussions of details that are of interest to themselves, but to no one else. Such details should be worked out by the staff agency that serves the committee, in coöperation with the particular members. Committee members should be prevented, if possible, from taking definite stands on proposals before all the facts have been developed. Some people tend to defend a position, once it has been taken. A committee reports necessarily to some superior line or staff executive. This executive should inform the committee promptly concerning what action has been taken on its recommendations and why. Otherwise its members will shortly lose interest in the committee's work. There are other measures that can be taken with different types of committees and circumstances to improve committee effectiveness. They cannot overcome inherent defects in committee organization and action.

STAFF EXECUTIVES

Staff executives may be classified on the basis of their duties, as follows:

1. *The organic function served,* such as staff sales executives, staff production executives, and staff finance executives. The comptroller is a common example of the latter.
2. *The managerial function served,* such as technical staff executives and coördinate staff executives. The head of a production control department is a common example of the latter.
3. *The echelon or level on which the service is rendered.* We have administrative executives and operative executives. Any staff executive who reports directly to the president or the executive vice-president is usually an administrative staff executive.
4. *The form of staff relationship.* We have seen that there are executives who render an occasional or intermittent staff service, such as consultants and committee members. There is also the exceptional instance of the staff executive who has been given some highly limited line authority.

The Law of Functional Growth

There are many other staff problems. They have to do with the maintenance of unity of command, staff releases of orders, the development of staff parallelism, effective use of headquarters staff groups, the limitation of staff economy, to mention a few. Some of them will be discussed later in the text. Most of them must be left for discussion in books on administrative management.[9]

Many managerial problems are the result of an increasing complexity of line and staff relationships. They are largely an effect of organization growth with increasing business volume. Functions must be differentiated

[9] See R. C. Davis, *The Fundamentals of Top Management,* Harper & Brothers, 1951.

from one another as the load of work increases. It is necessary to accomplish a division of labor and to provide needed specialization. New units, branches, sections, departments, and divisions must be set up as the organization continues to grow. Proper relationships between them must be established and maintained. Line devolution and staff evolution continue in different directions, but they must be coördinated. The situation has been summarized in a law of functional growth, as follows: The various functions of an organization increase in scope and complexity, as well as in the amount of work and the technical requirements for their proper performance, as the volume of business grows. The complexity of functional relationships tends to increase in geometric progression as the volume of work that the organization must handle increases in arithmetic progression.[10]

The Attributes of Good Organization

The importance of good organization in business success is evident. The characteristics of business organizations, and their structures of functional relationships, vary widely between companies. These differences depend largely on differences of objectives and leadership. There are, however, certain attributes of good organization that can be observed in most successful business organizations. The principal ones are:

1. Effective executive leadership.
2. Sound business objectives and policies, based on competent analyses of customer needs and desires, that have been made with due regard for the public interest.
3. Sound functional relationships, as determined by objectives.
4. Adequate logistical support of operations with money, materials, equipment, plant and other physical implementation. What is adequate is determined by the requirements for an effective, economical accomplishment of objectives.
5. A complement of abilities, both executive and operative, that is capable of accomplishing the mission.
6. Organizational stability.
7. Organizational flexibility.
8. Organizational capacity for growth.

[10] A. V. Graicunas pointed out, in 1933, that the number of subordinates reporting to an executive is an important factor in the complexity of the latter's job. He showed that this complexity increases in geometric progression as the number of subordinates increases in arithmetic progression. His theorem is particularly pertinent to the span-of-control concept. It is a part, however, of the general problem of increasing structural complexity with organizational growth. (See "Relationships in Organization," *Bulletin of the International Management Institute*, March 1933. Also, *Papers on the Science of Administration*, edited by Luther Gulick and L. Urwick, The Institute of Public Administration, Columbia University, 1937.)

9. Organizational balance.
10. Good organizational morale.

Comment on the first five attributes has been made previously. A brief comment only will be made on the remaining five at this point. It will be necessary to take them into consideration later in discussing various management problems.

Organizational stability is that quality of an organization that enables it to adjust itself promptly to personnel losses without serious losses of economy or effectiveness. An objective in the development of stability may be a minimum loss or dilution of the organization's skill and knowledge content as a result of personnel changes. Another objective may be a minimum of expense in connection with such changes as are inevitable. Lower executive salary costs may be possible in a stable organization, because the organization is less likely to be a necessitous buyer of executive ability in the open market. A result of organizational stability may be better morale. There may be other values that are the objectives of an improvement in stability.

The problem of organizational stability involves all ranks and grades of personnel. It is most serious in the case of executives, since they constitute the organization's leadership. The solution of the problem depends on the particular replacement difficulties. The methods used may include the analysis of the causes of executive turnover with a view to reducing it to a practical minimum. The development of a solution may require techniques for the determination of executive man-power requirements to replace turnover losses. Policy decisions must be made concerning the staffing of support positions for all executive jobs. One well-known concern frowns on the creation of assistant department heads or other seconds in command. It feels that such executives represent unnecessary salary expense in many cases. Another concern, that is equally successful, insists that each executive job be backstopped at least two deep at every organizational level. This problem may include also the determination of sources of replacement man power within the organization. The operation of an inventory record of individuals who are capable of development and advancement in the organization may be required. Executive training and development may be necessary. Executive losses should be replaced through promotion or transfer, as far as possible, and by the selection and training of executive trainees. The initial problems fall largely within the field of organizational planning. It is a top administrative staff problem in large concerns for this reason. The operation of training, promotion, and

other personnel procedures is usually handled by the personnel department.

Organizational flexibility is that quality of an organization that enables it to adjust itself to temporary changes in business conditions without serious loss of effectiveness. The problem is largely the result of seasonal and cyclical changes. The objectives in the development of this attribute may include many values. The ability to meet changing competition promptly is one value. The ability to adjust the organization promptly to changing loads of work is another. A reasonable relationship between wage and salary expense and changing business volume also may be an objective. Greater continuity of employment and income for permanent employees and other values may be needed. Some of the considerations and difficulties in the problem of flexibility have to do with business forecasting. It is necessary but difficult to determine the probable effects of changes in business volume on the organization. Effective man-power utilization is difficult during periods of expansion or contraction. Organizational flexibility requires the development of flexibility in people and in physical facilities. A flexible organization structure must be developed. The provision of flexibility in policies and procedures is a complementary requirement. The maintenance of good morale during periods of business change may be difficult. The solution of the problem of organizational flexibility depends again on top administrative policy decisions. It therefore depends on the quality of top leadership. The development and application of solutions requires coöperation between many subordinate line and staff groups.

Business success is usually the result of superior economy and effectiveness in serving the public over a period of time. The effect is increasing business volume. This, in turn, requires increasing organization size, whether measured in terms of scope of activities, invested capital, or people. Function is work. The term refers merely to groupings of related, homogeneous activities. There is more work to be done with more customer orders. There is nothing to be done, conversely, with no orders. Organization growth, then, is an effect of business success. It may become a requirement for continued success, when the particular business field is subject to continuous, rapid technological development. There are some economic advantages that flow from large-scale business organization and operation. One advantage has to do with greater ability to employ superior executive and technical brains. Another, usually is greater ability to increase *per capita* production by means of highly productive machinery

and equipment. Greater ability to engage in product and process development through research also is an advantage of large-scale operation. Decreased unit costs, improved customer service, increased profitability, and capital gains, are other advantages. Some executives receive public recognition for outstanding economic contributions. It is often granted unofficially to the leaders of great corporations, despite the fact that they are our favorite political whipping boys. These are a part of the rewards of business success. There are some disadvantages of large-scale organization and operation. These disadvantages have to do with the difficulties involved in maintaining morale with increasing growth. They are concerned with the loss of flexibility with increasing size. The interference of government in large-scale operations may increase the management problem. The tendency of profitability to decrease beyond a certain size of establishment must be watched. These are some of the headaches that are the penalties for success.

Capacity for organization growth is obviously an important factor in business success. Growth capacity may be defined as the ability of an organization to adjust continuously its structure, facilities, and personnel to permanent changes in business volume without serious loss of economy or effectiveness. Such adjustment requires permanent differentiations of functions, and their grouping in new organizational elements. The bases of functional grouping that were shown in Fig. 4.2 become increasingly important and evident with increasing growth. A sound solution of the problem requires obviously business forecasting and organizational planning. These phases of the problem are related to but different from forecasting and planning for organizational stability and flexibility. Growth planning is based largely on forecasts of the secular trend of the business. This planning involves chiefly long-range rather than short-range or intermediate planning. Many considerations must be taken into account. Some of them have to do with the character, direction, and rate of change of primary business objectives. Customer needs and desires are constantly changing in most industries. Other considerations have to do with the characteristics of the industry that either permit or inhibit growth. An abundant widespread distribution of required natural resources when combined with high transportation costs for the finished product, for example, may result in a large number of separate establishments. This does not necessarily inhibit corporate growth, however.

There are many financial and functional growth processes that should be understood. The former involve capital procurement from outside sources, or capital formation through retained profits. The processes of

functional growth have been summarized previously. It should be recalled, however, that the need for decentralization tends to increase with organization growth. The principles of decentralization and delegation are important considerations, accordingly. An organization is usually no better than its leadership. An important limiting factor in business growth is frequently the executive leadership of the organization. Plans are no better than the people who execute them. The execution of plans for business expansion is frequently retarded or stopped because competent people are not available to staff new executive jobs. The general method of approach to a solution of the growth problem therefore involves the estimation of long-term service demands on the organization. It requires the determination of the effects of secular growth on the organization. It must consider the effects of secular growth on executive and operative personnel requirements. It must estimate the effects of growth on capital requirements. Such studies must result in the development of sound plans for organizational growth. The above analysis is an oversimplification, of course, like most statements of general methods of approach.

Organizational balance is a condition in which the relative development of the various functions and organizational elements conforms as closely as practicable with their relative importance. The ultimate measure of importance is the worth of the contribution by a particular group to the accomplishment of the organization's primary service objectives—customer satisfactions. The determination of the value of a group's contributions may be difficult, particularly for staff departments. Staff contributions are made directly to the company's organization, but indirectly to the company's customers, in most cases. It will become evident later, nevertheless, that the contributions of some staff departments are basically important in successful competition. The management of an industrial concern may have some financial and operating ratios. These may show the typical relations between line and staff expense for the principal staff groups in the industry. This information may be classified by size of company. It may be the case, however, that the company may need more of a particular kind of staff service, such as marketing research, than the average company of the same size in the same industry. It must be supplied, if such service is needed for successful competition. The organization may need less of some other staff service, on the other hand. Any average expense ratio for the industry is excessive if we need none of the values that are contributed by the particular staff. The problem of staff organizational balance is important. Staff expense is overhead. It goes into the costs of our goods and services. The sales dollar must cover costs

and a reasonable profit, over a period of time, or the company may be forced out of business.[11] It should not be assumed, however, that organizational balance is solely a problem of controlling staff development and staff operations. There has been much discussion of automation in recent years. The term refers primarily to the development of automatic performance and control of certain functions. Some automatic production lines will be seen, shortly, when we look at the manufacturing plant and its equipment. These lines use what is known as "station transfer" equipment. Such equipment performs primary operative functions. It sometimes represents an investment of hundreds of thousands of dollars, or more. Some manufacturing executives have expressed the opinion that the point of diminishing returns in the use of such equipment can be passed, temporarily, under certain conditions of sales volume and product standardization. There is an unbalance in capital provision for the development of line departments when this happens.

The problem of maintaining organizational balance is inherent in every organizational development of any significance. No special plans for solving it are necessary, nevertheless. A satisfactory solution is a normal result of a sound application of management principles, and particularly those having to do with organization.

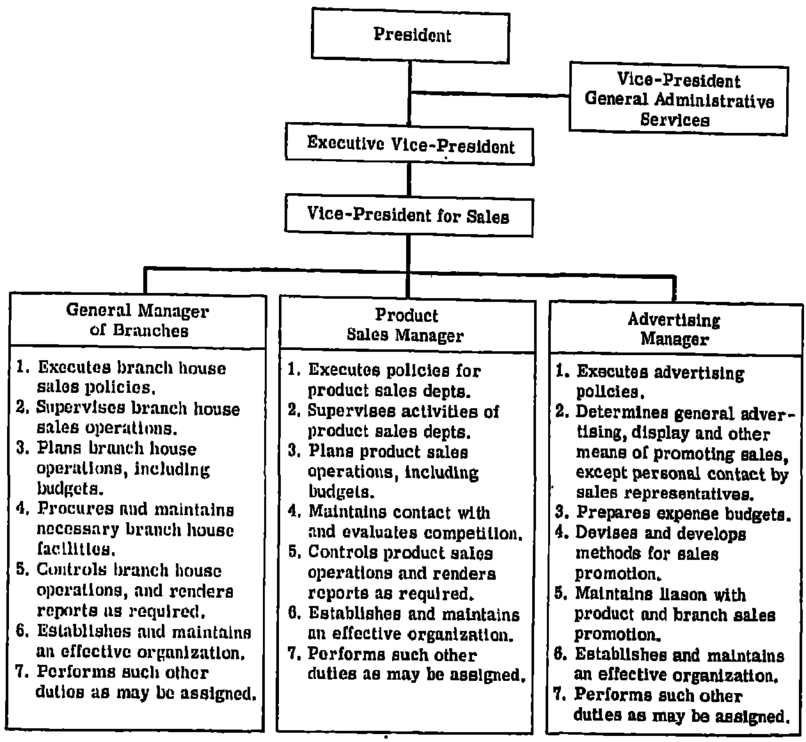
Organization Charts and Manuals

Policy manuals, organization manuals, and procedures manuals are likely to be needed increasingly with organizational growth. The one-man organization obviously needs none of them. The large corporation would find it impossible to maintain its competitive effectiveness without the development of some of them in some degree. A basic reason for developing any manuals is good communications for the maintenance of effective coöperation and coördination between organization groups.

An organization manual is chiefly a set of organizational specifications, illustrated by organization charts. Such specifications are based on job analyses and job specifications. The manual usually gives general informa-

[11] It is recognized that there are alternatives, such as government subsidies, government protection from competition, government-supported prices, state capitalism, and other measures that savor of socialism. They are incompatible with the American public's evident desire to retain a *competitive economy*. This requires free markets and free competition for the public's patronage. Costs must be reduced when the public decides that prices are high with respect to the goods and services that it buys, and refuses to pay. Price and cost reduction become necessary, regardless of theory or the pressure of groups having some vested interest in price maintenance. Most executives will not release competent personnel until it is necessary, however. Anyone can break up an organization. It takes much time, money, and effort by good executives to build a good organization.

tion concerning each organization element. This information may include its name, organizational location, title of its executive head, principal subdivisions, their objectives and duties, the responsibilities and authorities of the executive head, the chain of command in which he is located, the



Note:

The duties outlined above are performed under the general direction and supervision of the V.P., Sales. The manner of their performance is subject to the requirements of the general objectives and policies of the sales division, and the concurrence of designated staff groups, as set up in the company's organization manual. It is subject also to the general procedural requirements set up in the standard practice manual of the Sales Division.

Fig. 4.4. A "Functional" Type of Organization Chart

structural relationships between his group and others with which he must work, and similar information.

An organization chart is a graphic or semigraphic presentation of certain information concerning functions, functional groupings, and lines of responsibility, authority, and accountability in the organization. The details of organizational charting have no place in a general text on industrial management. It should be noted, however, that the respon-

sibility for the development of an economical, effective organization falls on the head of that organization. This responsibility may be limited of course, by inadequate delegation of authority. The method of charting that is used by one executive should be similar to that used by another, however. Otherwise, it may be difficult to compare the charts for one division of a company with another division. A few large organizations have found it desirable to develop a standard charting procedure for this reason. It is desirable, also, to have any major organizational developments within a subordinate staff group coördinated by a higher administrative staff group.

The details of charting may vary greatly between concerns, as indicated above. There are only two basic types of charts, nevertheless: the "inverted tree" type and the "functional" type. Figure 4.1 is an example of the former; Fig. 4.4 of the latter. There are certain requirements that should be met with any type. The charts should be simple and easily understood by the average user. It should be possible to produce them quickly and cheaply when organizational changes are necessary. These charts should be bound and filed in a manner that will make them readily available. They must be kept up to date. Other requirements can be found in monographs dealing with the problem of organizational charting.

Organizational Morale

Morale is a mental condition of individuals or organizations. It determines their attitudes. Hence it limits the degree of their acceptance of leadership. It conditions the quality of their coöperation in the accomplishment of organizational objectives. Great leaders in any field of human activity have always recognized the basic importance of morale.

The general obligation of private enterprise to make a continuous contribution to an increasing standard of living has been noted previously. An increasing standard of living depends on increasing *per capita* production. The latter depends largely on an increasing application of productive capital with increasing effectiveness. It depends also on increasing worker effectiveness in the performance of manual operations. This is a result chiefly of motion-and-time study and other process planning techniques, as well as good training, supervision, and other management contributions. Process planning, accordingly, is an important management function in the development of industrial economy and effectiveness. Management provides initially the necessary physical facilities and conditions, in performing its function of organizing, as well as money, methods, initial inventories, and man power. Management does

these things, acting as an agent of ownership. Effective use of physical facilities depends, nevertheless, on the attitudes of the organization's executive and operative employees. Morale therefore is a limiting factor in productivity. It is a limiting factor, accordingly, in the ability of the business organization to accomplish its primary service objectives with the required economy and effectiveness. Such accomplishment is a prerequisite for continued profitable operations. The interest of industrial executives in the morale problem has increased greatly since World War II. One reason is obvious: A recognition of the importance of good morale in organizational effectiveness, as a result of union activities over the past 20 years. It is probable that this interest would have developed anyhow, because of the fundamental nature of the problem.

The reasons for the expenditure of large sums of money on morale development are the organizational effects that are produced: A favorable state of mind among the individuals and groups composing an organization. Such a mental state is reflected in favorable attitudes toward the organization, its work, and its leadership. Good morale is reflected in higher degrees of willing coöperation, loyalty, good discipline, and other effects that are equally important. The director of industrial relations and personnel usually has staff responsibility for morale development. The primary responsibility for group morale rests on the head of the group. We shall discuss methods for accomplishing this mission when we come to the work of the personnel department.

PROBLEMS

1. A large electrical manufacturer regards its primary divisions as sales, production, engineering, and finance.
   (a) Why does it make any difference how they are regarded?
   (b) Do you or do you not regard them as line divisions of the company? Why?
   (c) Some companies regard finance as a staff function in a manufacturing organization. Some regard it as a line function. What do you think, and why?
2. A large export company did business all over the world. It operated assembly plants in many countries. It was necessary to manufacture or buy certain materials or parts requirements within some countries. This was due often to legal or competitive restrictions on trade. The company's president had an assistant and a general manager who reported directly to him. The following executive personnel also reported directly to the general manager: a general manufacturing manager, a general supply manager, a general sales manager, a general finance manager, and two assistants. The company's export business was divided geographically into regions. A director was in charge of each region. The regional director was completely accountable

to the general manager for results accomplished in his region. A regional production manager, a regional supply manager, a regional sales manager, and a regional finance manager reported directly to the regional director. Each region was divided into zones. The zone managers reported directly to the regional director. Each zone manager had a production manager, a supply manager, a sales manager, and a finance manager. The relations between the general manufacturing manager, the regional production managers, and the zone production managers were strictly staff. The other functions, at the headquarters and regional levels, also maintained a staff relation with corresponding functions at the zone level.

(a) Make a chart showing the organizational structure of this company.
(b) The president considered the organic functions of this business to be production, supply, sales, and finance. Do you agree or disagree with him? Why?
(c) What difficulties might arise from an inaccurate analysis of organic functions, in this case?
(d) What are the fundamental bases for the division of functions, responsibility, and authority that have been used?
(e) The office of the general manufacturing manager was in New York City. It was necessary for him to travel extensively, of course. How would you classify functionally the general manufacturing manager?
(f) What do you regard as the line organization of this concern? Why?

3. The work of purchasing in a small manufacturing organization has been handled by a purchasing agent and his secretary, but the volume of work has grown to the point where they cannot handle it satisfactorily. The firm has decided to combine the recording and checking of invoices, the routine follow-up of purchase orders, the recording of deliveries on orders, and similar work, into a separate job and to hire a clerk to handle it.
(a) What kind of organization element has been created?
(b) At what stage of functional differentiation is the company, so far as purchasing is concerned?
(c) What is the nature of the division of responsibility that has taken place?
(d) What is the significance of these distinctions in this case? How do they relate to any further growth and development of the purchasing function?

4. The board of directors of a well-known manufacturing company has issued periodically, during the past 35 years, a statement of its general policies. There has been very little change in the wording of the statement during this period, despite the fact that there have been substantial changes in the membership of the board.

Each statement of general policy is intended to be broad and basic. The following are examples of statements in this manual: "First: To do business guided and governed by the highest standards of conduct and ethics, striving always for that sort of an ending in all things affecting the conduct of the business as would make 'reputation' an invaluable and permanent asset.... Third: To make every possible effort to develop and maintain a contented, efficient, loyal, aggressive organization, who believe in their Company, to

whom work is a pleasure, and to whom extraordinary accomplishment is a personal ambition. . . ." Some cynical people might feel that such statements are merely a pronouncement to the effect that the board of directors is against sin, which is always commendable, of course. Such people might suggest that such a policy statement is useful chiefly for public relations purposes, and for hanging on the wall of the president's office. The executives of this organization, at all echelons, feel nevertheless that this statement has contributed greatly to the development of good morale in the company's operative organization. This company is well known, in fact, for its good relations with its employees. The industry that includes the company is strongly unionized. Between 60 and 70 percent of the company's operatives belong to the dominant union. The remaining operatives are members of an independent union. This company is engaged in multiplant operations at widely separated locations. An inspection of its financial statements would show that it is successful financially.

(a) We may assume that the directors and executives of this company are practical men, since the company is successful and has been. What practical value can there be in a policy statement of this kind? What possible use of such a statement could we make if we had one in our organization? How can you relate such a statement to the general, major, and minor operating policies of the company?

(b) We may assume also that there is some causal relationship between the board's general policy statement and good morale in this organization. What does it take, in your opinion, to make such a statement a strong, positive factor in the development and maintenance of good morale?

5. In a large organization, the sole right to hire and fire was vested in the personnel department; the operating department head had the right to lay off men who were not needed or were unsatisfactory, but he could not discharge them. When an operating department head needed additional employees, he made out a labor requisition, had it approved by his line superior, and sent it to the employment section of the personnel department. On receiving the requisition, the employment section would interview applicants for the job, select the person who appeared best suited to the work and put him on the payroll. The employment section would tell him where and when to report for work. It would notify the operating department head under whom he was to work. In many cases the new man would remain in the department for only a week or two. At the end of this period the department head would return him to the personnel department as unsatisfactory. The reasons were always excellent but usually difficult to check. The personnel department adopted the policy of sending all applicants to be interviewed by the head of the operating department concerned before any man was finally hired. Shortly thereafter, layoffs of this type began to decrease materially in number.

(a) How would you classify the personnel department's function on the basis of type and kind?

(b) From the point of view of employment, how would you characterize

the relation between the personnel department and the operating departments before the change in policy?

(c) What change did the personnel department's policy make in this relationship, and how fundamental was it? Why did the operating department heads tend to lay off the newly hired men?

(d) In your opinion, what principles of good organization may have been violated previous to this change? Why?

CHAPTER 5 •

• Business Control and Procedure

The Nature of Control

CONTROL is recognized generally as one of the organic functions of management. It is the function of constraining and regulating action, in accordance with plans for the achievement of specified objectives. The constraint of action has to do with confining the various activities within the limits that have been predetermined by the plan. The regulation of action has to do largely with the maintenance of a predetermined time rate of performance. Such regulation is necessary for effective coördination.

Objectives of Control

The ultimate objectives of control are, of course, the primary service objectives of the business. These are more customer values of better quality at lower costs and prices, together with satisfactory delivery and service. The immediate objectives of control are derived from the objectives of the particular plan. They have to do chiefly with:

1. Assurance of correct performance, as specified by the plan
2. Well-coördinated action, to accomplish the mission with a minimum of time, effort, and expense
3. A minimum of losses due to interferences with the proper execution of the plan

Coördination

Coördination has been defined previously as the development and maintenance of a proper relation of activities, either mental or physical. It was noted that it has two principal phases; the coördination of thought and the coördination of action. These phases are related, but they present quite different problems. The coördination of thought has to do primarily with the relation of mental activities. It is an important part of the work of planning.

The coördination of action has to do primarily with the relation of physical activities, with respect to time and the correct order of performance, as they enter into execution. Coördination of execution therefore depends on a sound procedure for the creation of the required end values, and the correct timing of the steps in the procedure. The purpose of coördination is to assure a cumulation or build-up of values into an end result that will meet the specifications of the mission. The coördination of the work of producing an assembled product is an example. There is usually a standard procedure for the production of each part. This procedure may be called the "operation list," "plan of work," or by some other name that someone thinks is descriptive. Such a procedure is an operative plan for making the part in conformity with product specifications, by whatever name it is called. An illustration of such a process plan will be seen in Fig. 9.7. It will be noted that the steps, or "operations," required to make the part have been listed in the order of their performance. The departments in which the various operations are to be performed are specified also. The amount of time that should be required to complete a standard quantity, or order, of these parts also has been specified. Such information is necessary for the coördination of production with respect to time and the order of performance. The provision of this information is part of the jobs of routine planning and scheduling. This will be seen when the work of production control is discussed.

Importance of Control

The importance of the control function has been indicated generally by the previous statement of control objectives. A plan specifies what is thought to be the most effective action, using the best conditions and performance factors. Control sees that the required information concerning the plan is released to subordinate organizations. Effective use of materials, equipment, and man power requires timing. It is costly to have any one of these factors idle while performance waits for the others. Control sets up schedules that supply the basis for time coördination. Control assures that the required performance factors will be available when needed. It enables executives to perform properly those leadership functions of direction and supervision. Control aids these executives in overcoming difficulties and interferences with performance through sound corrective action. It performs other services that enable the organization to accomplish maximum results with a minimum of expense. Many difficulties are encountered by executives when they attempt to lead an

organization to a successful and profitable accomplishment of its objectives without good controls. Control is regarded for such reasons, as an organic management function.

Functions of Control

Control breaks down into its elements, like any other problem. These elements are the various phases, or subfunctions, of control. We shall refer to them usually as control functions.

There are only 8 basic control functions, in the opinion of this writer. There are many kinds of control procedures in industry, however. Some of them have to do with the constraint and regulation of primary activities, such as production, distribution, or finance. Some of these procedures

Normal Order of Performance	Relation to Execution	Control Subfunctions	Organizational Assignment	
			Line	Staff
1	Preliminary Control Functions	Routine Planning		✓
2		Scheduling		✓
3		Preparation		✓
4		Dispatching		✓
5	Concurrent Control Functions	Direction	✓	
6		Supervision	✓	
7		Comparison		✓
8		Corrective action	✓	

Fig. 5.1. The Organic Control Functions

have to do chiefly with the coördination of line and staff activities. General administrative control procedures for coördinating progress in new product development, design, and production are usually a good example. We even have procedures within large staff departments and divisions for the internal control of their operations. Any control procedure is a structure of the 8 control functions in various forms, combinations, and arrangements, together with the human and physical factors in their performance. A control problem therefore can be analyzed in terms of (a) the objectives of the particular plan whose execution is being controlled, (b) these basic control functions and their requirements, and (c) the control principles that are applicable in the particular situation. The 8 control functions are (1) routine planning, (2) scheduling, (3) preparation, (4) dispatching, (5) direction, (6) supervision, (7) comparison,

and (8) corrective action. The general relationships between them have been shown in Fig. 5.1.

Routine planning is the function that makes a routine provision of information concerning the particular plan and the requirements for an economical, effective execution of it. This function makes a secondary determination of what should be done, who should do it, where the action should take place, who should be responsible for it, how much time is required for each phase of the program or step of the project, what physical and human factors are required, and similar information. The primary or original determination is made usually by some technical staff group acting for the responsible line executive with his approval. An important duty of routine planning, therefore, is the coördination of technical staff planning with the requirements of the organization for plans information. Performance of the routine planning function may require little more than picking the necessary information out of a file in a control office, when it has to do with a standardized, repetitive project. An example would be the production of a standard part in a standard quantity for stock. Routine planning requires a prior original determination, obviously, when the project cannot be standardized and is not repetitive.

Scheduling determines when or at what rate the principal phases of the plan must be completed to meet the final time objective of the project. This function has to do largely with the conversion of quantitative time requirements, as set up in the plan, into chronological time objectives for the project and each of its phases. Scheduling can range in scope from the determination of deadlines for the completion of the principal phases of an engineering design program, down to the determination of starting and finishing dates for each operation on an order of parts.

Preparation is the function that assures the availability of the various performance factors and conditions, when, where, and as needed. These factors and conditions must be available, of course, in the required kind, quantity, and quality. The actual work of providing the necessary factors and conditions is not the responsibility of control. It is usually the responsibility of some technical staff department. A central manufacturing control department, for example, may coördinate the work of our purchasing department with the requirements of the production line departments for purchased materials. This control department performs no purchasing, or storing, or any other supply functions. The same thing should be true for its relations with the personnel department or any other technical staff group. The principal mission of preparation, then, is to coördinate the

provision of certain technical staff services of facilitation with the needs of the agencies which use these services in executing the plan. The purpose of preparation is to anticipate and eliminate in advance any interferences with execution that would arise because of a lack of the required performance factors and conditions. It is folly, and it may be fatal, to issue an order without reasonable assurance that it can be executed.

Dispatching is the function of assuring proper time coördination by means of a controlled release of authority to act. This function accomplishes its mission by withholding the authority to act from subordinate units on lower levels until danger of a breakdown of time coördination, due to premature action, has been reduced to the practicable minimum. A *carte blanche* release of authority to act can result in a serious breakdown of control. This is particularly true when the release is made too far in advance of the scheduled date for the completion of the action. The correct time by which dispatching should lead execution depends largely on the nature and extent of the delegation of responsibility and authority to subordinate executives. It must include sufficient time to permit these executives to establish control of the particular action. This lead time therefore depends on the conditions and requirements governing the decentralization of control. It is affected by the type and kind of industry and manufacturing. These matters also will be discussed later, in connection with the problem of production control. There is considerable confusion in the literature of management concerning the dispatching function. This may be due to the use of the control department, in many concerns, as a coördination center for the release of technical staff information concerning primary operations. We may forward information to primary shop departments, for example, concerning the product and the conditions and methods for its manufacture. This may be done when production orders are released. This is a facilitative service of control that is accomplished, in part, through dispatching. It is not dispatching, however.

Direction is a function of instruction concerning the nature and requirements for the proper execution of a plan. Routine instruction obviously can be accomplished through written directions. The required information may be received originally from various technical staff departments. This information may be processed and forwarded by control, as a result chiefly of its routine planning and dispatching functions. The leadership phase of direction, however, is that of oral instruction. The primary purpose of such instruction is the constraint and regulation of action by explanation, interpretation, and demonstration if necessary. Direction

supplements the information and instructions that are supplied by higher authority. Command is the function of authoritative direction. Oral direction is a command function that usually involves face-to-face leadership. The manner in which it is performed is an important morale factor, accordingly.

Supervision is the function of assuring that execution is taking place in accordance with plans and instructions. The purpose of supervision is to determine whether subordinate personnel understand previous directions, and are following them in a manner that will result in correct execution. This function evaluates, through visual observation, the progress of the action and detects current interferences with it. It can lead directly to corrective action, in consequence. There are some routine aspects of supervision that can be delegated. Staff inspection can relieve the responsible line executive of some of the work of supervision. The inspection function of any staff department must be set up in a manner that will avoid any breakdown of line responsibility, however. The most important phases of supervision are personal and visual, nevertheless. Supervision involves face-to-face leadership, like direction. It is also an important morale factor, for this reason. Direction and supervision are the only two functions that can evaluate and control action directly while it is taking place. The other functions of control must be performed largely before the initiating of action, on a particular phase or step of an undertaking, or after its completion. It should be noted also that on-the-job training is largely the result of direction and supervision.

Comparison is the function of evaluating completed performance in terms of the objectives of the original plan. The criteria of accomplishment are in terms of the quantity, quality, and cost of the required results, relative to time. Comparison therefore is concerned with determining the degree of agreement between actual and planned results. This determination may be made for each critical step or phase, as well as for the undertaking as a whole. Comparison notes the deviations from planned performance. It records the interferences with operations that cause them. It reports results, variances from planned performance, and the causes of deviations to higher authority for corrective action. The various groups whose work is being coördinated must report periodically to the staff control group. These reports should show the nature and extent of the progress that the particular groups are making in accomplishing their assigned missions. The control group "feeds back" summarized progress information to the operative executives who are immediately responsible for execution. The reporting groups may be units, branches,

sections, departments, company divisions, or corporate divisions. The kind of reporting unit is important: There is usually a significant change in the kind of control that is necessary between one major organizational echelon and the next higher. Most of the work of control at the level of supervisory management is project control. There is, or should be, some group control, however. Most of the work of control at the level of top administrative management is group control. Top executives come in contact with the control of major projects, occasionally, when a general policy decision becomes necessary. The kind of progress report will vary also with the organic and structural nature of the group. It will depend, obviously, on whether the group has to do principally with production, distribution, or finance; whether it is line or staff. It should report, in any event, what results have been accomplished, in terms of quantity, quality, and expense, when and where these results were accomplished, who was responsible, and what difficulties are interfering with the accomplishment of the required results. It is therefore evident that the comparison function breaks down into four principal subfunctions or phases:

1. The receipt of returns or reports by the control department for the responsible line executive whom it serves. These reports may come from individuals and groups who are not under his command, when their activities affect substantially his discharge of his responsibilities. Returns will be reviewed, of course, from those groups that are under his command.
2. The accumulation of information concerning results that has been reported. This information must be analyzed and sometimes reclassified, to make it of value for control purposes. It may be necessary to accumulate it in any event, since continuous comparison often is unnecessary and too expensive.
3. The periodic evaluation of completed action to date. This is the phase in which we make a comparison between actual and preplanned performance for the steps in the accomplishment of the mission that have been completed.
4. Report of the status of accomplishment to higher line authority. It is usually necessary to supply copies of progress reports to other coördinate and subordinate executives who have some significant responsibility for it.

The time of the responsible line executive may be very expensive. He may be performing a very vital leadership function. It is desirable, for a number of reasons, to conserve his time. Phase 4 in the above analysis requires an application of the *exception principle* in consequence: only the significant deviations of actual from planned performance should be brought to the attention of the responsible executive.

Corrective action is the function of correcting deviations from planned performance, when they exceed normal limits of variation. The correction of deviations should be made promptly by subordinate personnel on

lower levels whenever practicable. Such corrections, wherever made, may require an adjustment of the nature of the action, the removal of interferences with performance, the provision of additional resources, or other provisions. The status report, noted in Phase I under "comparison," may come in writing from a control group, or orally from a subordinate executive in an emergency. The control group should be informed promptly, in the latter case. The mission of corrective action, in either case, is the prevention of a failure of the mission to accomplish its objectives because of continuing, significant deviations from planned performance. The importance of the action, and the necessary decisions concerning it, are such that corrective action is usually a personal responsibility of the line executive at the level where the deviation is taking place. It becomes a personal responsibility of his superior when for any reason the subordinate executive is unable to handle the situation satisfactorily. The superior executive must carry the ultimate responsibility for results, regardless of the extent to which he has delegated responsibility and authority. Corrective action also breaks down into certain subfunctions or phases, as follows:

1. *The operative phases*
   a. Prompt investigation of the causes of the deviation
   b. Decision concerning the required corrective action
   c. Prompt direction for correcting the situation in accordance with the decision
   d. Close supervision of corrective action to insure that it is taking place in accordance with instructions, and is effective
2. *The administrative phases*
   a. Further investigation of recurring difficulties to determine the basic factors, either human or physical, that are responsible
   b. Disciplinary action, either positive or negative, as the situation requires
   c. Creative planning to prevent a recurrence of the situation
   d. Reorganization of the situation and the introduction of the planned measures

The operative phases of corrective action are concerned chiefly with the correction of some situation that imperils the success of a current project or a program. These phases involve chiefly expedient action, or at the most short-range planning. The administrative phases look forward to a permanent correction. They seek to improve the general situation as it will affect similar projects or programs in the future. It may have little to do with the current undertaking that is in difficulties. The administrative phase is concerned chiefly with long-range planning and organizing. It therefore may be performed on a higher level of administra-

tive management than that on which the immediate problem is being solved. Many different line and staff groups may be pulled into the various phases of corrective action. This will be seen later when the functions of the manufacturing organization are discussed in more detail.

Preliminary and Concurrent Control

Control has been defined as the function of constraining and regulating action to assure the accomplishment of designated objectives as planned. It is therefore evident that the control of an action must be established before that action commences. It is for this reason that we have distinguished between preliminary and concurrent control functions in Fig. 5.1. A review of the preceding discussion of organic control functions will show that there must be some minimum performance of the functions of routine planning, scheduling, preparation, and dispatching before the action to which they relate commences. Otherwise, there can be no adequate control of this action, whether it has to do with the completion of a project as a whole or merely a step in its completion. The phase of preliminary control ends with the function of dispatching. The latter is the function that initiates action through a release of authority to act. We may have a routine performance of dispatching by a staff control department. Dispatching may be combined with direction, however, when for some reason the responsible executive takes personal command of the action.

The functions of direction, supervision, comparison, and corrective action tend to be performed concurrently with the completion of the required action. It is theoretically possible for an action to be planned, and organized so perfectly, and for preliminary control to be performed so well, that no concurrent control is necessary. It is not possible practically, regardless of managerial brilliance, because there are too many economic, political, and social factors that are beyond executive control. The action is closed out for a step or steps, or for the project as a whole, by the function of comparison, modified by corrective action when necessary.

Some students of management have oversimplified the problem of control. They have reduced it, in some instances, practically to the functions of scheduling, comparison, and corrective action.[1] These functions merely establish a basis for expedient measures to handle some interference with a planned action. It may be presumed that the interference

[1] Some students of management use the term "evaluation" to designate comparison. When they use both terms, evaluation may refer to comparison on the level of administrative control.

was not anticipated, or no advance provision for handling it could be made. Otherwise, it would not have arisen. There can be no control of that part of an action that has been completed. There can be some control of only that part which remains to be accomplished. The functions of concurrent control also deal with future action, since they are chiefly effective with respect to steps in the accomplishment of a project that remain to be performed. The exception to this statement is the function of supervision, which can lead directly and immediately to the correction of deviations from planned performance while action is in progress.

Operative and Administrative Controls

A distinction was made in Fig. 3.1 between administrative management and operative management. It is evident that a distinction must be made also between administrative control and operative control, since control is an organic function of management. The distinction, briefly, is this: operative control is project control. It is the control of action by individuals or groups in the completion of the steps that are necessary to accomplish a specific undertaking. A common example in industry is production control. There are some types of industry in which it is necessary to manufacture goods in relatively small quantities. Production orders are issued, authorizing the manufacture of the finished goods and their component parts. The required work will employ our labor and equipment for only short periods of time. We must find other work for this labor and equipment. It is often necessary to originate certain routine instructions for the completion of each order, and perhaps for each step. It may be necessary to set up a time schedule, showing when the work on an order should be completed in each department that processes it. It is necessary usually to check the availability of materials and machine capacity for the completion of the order as scheduled. The progress of the order should be checked periodically to make certain that the order will be completed as scheduled. There is other work of order control that must be done. Costs will be high, capital turnover for work in-process will be low, customers will be dissatisfied because of broken delivery promises, and many other difficulties will develop if this work of production control is done poorly. A clearer picture of this work will be obtained when we look at the job of a production control department under the conditions stated above. It is sufficient at this time to note that this managerial work has to do largely with the setting up and application of constraints and regulations to the completion of specific operative

work projects. This work includes, of course, the evaluation of results that have been or are being accomplished.

Administrative control is group control. It is the control of action by individuals and groups in the completion of programs for the accomplishment of group objectives. These groups may be any organizational components of the company, such as units, branches, sections, and divisions, to which individuals are assigned. These individuals work under supervisory executives, such as unit chiefs or group leaders, if they are operative employees. They work under the supervision of higher executives, if these individuals are executive employees. These individuals, in every case, are expected to make at least some minimum contribution to the accomplishment of the objectives of their group. The group program states usually the general projects or undertakings that should be accomplished during a coming time period. It is expected that the values resulting from a satisfactory completion of the program will constitute a satisfactory achievement of group objectives. These values are expressed concretely in terms of quantity, quality, and expense, as well as time. The primary objectives of the business organization, and the immediate objectives of every line group in it, are customer values. The program for a staff division of a company is supplementary to the programs for the line divisions, and the company as a whole. The general projects in a program, whether line or staff, break down into a number of specific projects. The program for the manufacturing division of a company, for example, may call for the production of 10,000 units of product A during a given month, as well as other quantities of other products. It is the responsibility of the vice-president in charge of manufacturing, to produce the 10,000 units in the most economical manner that will meet the delivery requirements of the sales division's program, inventory requirements, and others. He has the authority to make the necessary decisions, subject only to general administrative supervision. His production control department may recommend that we produce the 10,000 units in 20 lots or orders of 500 units, each. This recommendation represents, presumably, the best solution of the problem under the particular circumstances. The control of the action for the completion of each order is operative control. Each shop department that performs certain operations on an order reports the results of its work to production control, an operative staff department. Production control may initiate operative corrective action, if necessary. It summarizes, in any event, the results that have been achieved to date by projects and departments, and forwards its report to some higher

administrative control group. We build up here a picture of the results that are being accomplished, by programs and organizational divisions, in terms of quantity, quality, expense, and time. We compare the cumulative totals of results, as we progress through the month, quarter, or other time period, with the original objectives for each division and the company as a whole. We are able to tell whether or not a particular group is doing a good job, in so far as results are an indicator. It will be seen that the concurrent administrative control functions depend to a considerable degree on good operative controls.

The significance of this distinction between operative control and administrative control is of basic importance. Operative control is concerned with project action. It is concerned with the creation or distribution of values that are needed in the immediate future, either by the customer or the organization. Administrative control is concerned with group action over a period of time. It is more interested, accordingly, in long-term results rather than short-term effects. An important contribution of administrative control is the evaluation of the effectiveness of each group leadership in the accomplishment of assigned group objectives. The development of administrative controls at every executive level is a major managerial problem, since no organization can be any better than its leadership.

Decentralized Control

Decentralization takes place when some higher central source of responsibility and authority assigns certain functions and duties to subordinate individuals and groups for performance. The decentralized functions may be operative or managerial, or both. Their decentralization is accomplished through delegation. Any assignments of functions to subordinates should be accompanied by an adequate delegation of responsibility and authority.

The trend in American industry is in the direction of greater managerial decentralization. There are many reasons for this. It relieves the responsible executive of much of his burden of managerial work. It results in speedier execution of plans. It aids in executive development. It gives subordinates a greater feeling of constructive participation. There are other advantages that have been noted previously. It does not follow that complete decentralization is desirable, however. It would not be practicable, as a matter of fact, since complete decentralization is abdication. The degree of decentralization that is most economical and effective must be determined for each kind and condition of business.

Managerial decentralization includes the decentralization of control in whatever degree is necessary. Control is decentralized in some degree when the responsible executive has assigned the work of controlling a particular action to a subordinate executive who is closer to the point of performance. The assignment of the work of constraining and regulating action should be accompanied by an adequate delegation of responsibility and authority for control. It is difficult to hold a subordinate accountable for results when he cannot control his situation. The results that one gets from subordinates tend to vary directly with the extent to which they can be held accountable for satisfactory performance, as measured by fair standards. A purpose of control is the establishment of accountability. Complete accountability usually cannot be established. There may be too many factors that are beyond the control of the organization, as well as the individual.

Increasing decentralization of control results in an increasing separation of administrative control from operative control. Top executives of large companies are concerned chiefly with administrative controls of their organization's work; bottom executives chiefly with operative controls of project work; middle executives with some relation of both types of control. It is evident that the amount and scope of delegation must increase with organizational growth. Some executives are unable to delegate sufficiently, without losing control of the activities for which they are responsible. They may fail as a result. An important reason may be a lack of understanding of administrative control.

The volume of production and standardization of products are important factors in the decentralization of control. Increasing business volume, standardization, and organization size usually require a considerable decentralization of administrative controls. These same factors, on the other hand, may cause a higher centralization of production control than would be desirable in a plant that is manufacturing nonstandard products.

Line and Staff Phases of Control

Controls can be applied, of course, to any field of activity of the business organization. This is the case whether the activity has to do with the work of production, distribution, finance, or some staff organization. Controls can be applied at any managerial or operative level of the organization. The nature and details of the appropriate controls will vary with the type and kind of business activity, of course.

The work of control can be differentiated into its line and staff phases. This has been done in Fig. 5.1. It will be seen that the line functions of

control are direction, supervision, and corrective action. There are some minor routine phases of these functions that can be assigned to a staff control group. The more important and significant phases, however, must be performed by the responsible line executives for their subordinates. The reason is that these functions require decisions that are nonroutine. These decisions may have a direct and important effect on the accomplishment of the particular mission. Such decisions involve face-to-face leadership of the executive's immediate subordinates. These are a part of the executive's leadership responsibilities. The executive cannot delegate the authority to make such decisions to a staff control executive, for this reason.

The staff phases of contol are routine planning, scheduling, preparation, dispatching, and comparison. These are preliminary control functions, with the exception of comparison. Much of the work of performing these functions is operative, and can be assigned to clerks. This tends to be routine and repetitive. Little or no specialized, technical knowledge is usually required. It is often possible to standardize the procedure for performing these functions. It is therefore possible to differentiate these functions largely from the line functions of control. It does not follow, however, that the head of a staff control group is merely a chief clerk. Unexpected contingencies and interferences with operations are frequently arising in any business. A clerk can handle the routine of control, but not the exceptional situations and the interferences. The manager of a primary control department has an important position of staff executive leadership.

This distinction between the line and staff phases of control is helpful in organizing a staff control group. It will be seen, by reference to Fig. 43 that the 5 staff phases of control can be the basis for planning the organization of a control department. It should be remembered, however, that there is no formula for organizing, including Fig. 12. In a small shop, consisting of the owner-manager and a dozen operatives, there is no staff control department. The function of control is there, nevertheless, and must be performed personally by the boss to the extent that he can. A control department may evolve some years later, with the growth of the business. Whether or not it has two, five, or more sections within it, will depend on the situation at that time.

Significance of Control

The control function is much more controversial than the other organic management functions—creative planning and organizing. Control plays a significant part in establishing accountability, for one reason. It is natural

for most people to avoid the unpleasant necessity for an accounting of their contributions to the organization's success. These contributions are the principal justification for personal remuneration, however. Any payments for services come ultimately from the customer's dollar.

The control function can either improve or break down morale, depending on how it is performed. Certain control functions supply the basis for a just disciplinary action, both positive and negative. Inability or lack of courage to take justifiable disciplinary action leads to a breakdown of discipline. It causes low morale in consequence. A continued interference with control generally leads to the defeat of the current executive leadership in its efforts to accomplish the organization's mission. A continuing loss of confidence in the organization's leadership also leads directly to a breakdown of organizational morale.

There has been a tendency among a few students of management to avoid the use of the term "control" in discussing management problems. It appears to be a reflection of a vague feeling that the control of an organization's activities by its executive leadership is "undemocratic" in some respect. The business organization is neither democratic nor undemocratic. The terms apply to a political institution. The business organization is an economic institution. It is a part of the technique of political change to alter gradually the meaning of established terms. There is nothing in the function of control that prevents freedom of action or the exercise of initiative, within established limits. These limits are established basically by the requirements for a successful accomplishment of assigned objectives. Participation in planning, followed by delegation and decentralization in the maximum degree that is practicable, is common in American management.

Any subversive group that wishes to take over an organization will attempt to interfere with the normal operation of control methods. It will obstruct the course of normal disciplinary action. Such a group will weaken confidence in the organization's leaders. It will prevent the organization's executives from exercising leadership if possible, and will break down morale by any means. The same results can be accomplished, unwittingly, by some group within an organization that is forcing the satisfaction of its short-term personal objectives at the expense of the organization's long-term objectives. The importance of good control therefore extends beyond the necessity for getting out production to meet current customer orders. The standard of living and the military security of the country depend on the effectiveness of its industrial establishment. This effectiveness depends largely on an effective performance of man-

agerial functions, including control. The maintenance of the control of the industrial organization by its duly constituted executive leadership should be a matter of general public interest.

Business Procedure

Business procedure is one of the basic factors in business organization and operation.[2] Procedure and organization structure are related directly to one another, as was shown in Fig. 2.5. Both are structures of relationships between functions, physical factors, and personnel. They differ fundamentally from one another, nevertheless. A procedure is set up for the purpose of coördinating and facilitating the accomplishment of some type of project. It does this by breaking down the work of completing the project into steps or operations. It arranges these steps in a logical order, to facilitate a build-up of values into an effective, economical accomplishment of the project's final objectives. A basic consideration in procedural planning therefore is the complementary and sequential relationships of functions, physical factors, and personnel that must be maintained. The organizational location of the human abilities and physical facilities required for each step obviously must be considered. This location determines largely the routing of work through departments or other organizational components. The specific characteristics of these functions, performance factors, and relationships in a particular procedure are determined by the requirements for a successful achievement of project objectives.

An example of a standard procedure is shown in Fig. 5.2. It takes time and money to develop such a procedure. It must be kept up to date, furthermore, or it may be more harmful than helpful. Therefore it must produce values that are worth the expense. The following are some of the objectives: A business procedure introduces orderliness and uniformity in the execution of projects. It facilitates the differentiation of functions on the basis of their requirements for skill and knowledge, and hence it provides opportunities for specialization, and for a more economical and effective utilization of human abilities. It relieves the executive of many routine phases of planning and control, thereby freeing him for more creative activities.

[2] The terms "methods" and "systems" are used also to designate business procedures. The term "system" usually refers to a formal, stated, and standardized procedure, however. Its meaning, therefore, is largely synonymous with that of "standard office procedure" (SOP) or "standard practice instruction" (SPI). The significance of standard procedures will be noted shortly.

Methods Standard Release

NUMBER 107

DATE May 2, 1956

SUBJECT Coding - Premiums - Statistical Records, (Mechanical Calculation of Line 01 Renewal Premiums, Phase IV-Verification of Premium and Statistical Codes)

CODE 39, 73, 88

1. UNITS INVOLVED: (Auto Company)

   Regions: (HARRO and PHIRO) Accounting Services - Statistical and Underwriting Services.

   Staff: Electronic Development Department, Auto and Fire Statistical Division.

2. MANUAL AFFECTED: Underwriting Services - Line 1

3. EFFECTIVE DATE: HARRO - April 25, 1956 Day's Work
   PHIRO - April 25, 1956 Day's Work

4. CONCURRENCE: J. Russell, Auto and Fire Statistical; R. S. Conley, Internal Audits; E. A. Loviner, Electronic Development; H. Doyle, Auto Staff Accounting, HARRO and PHIRO.

5. BASIS: Machine Program developed by the Electronic Development Department and augmented by procedures developed by Electronic Development Department, Methods Department, UNYRO, METOR, NEOR, HARRO and PHIRO.

6. ATTACHMENTS: (2)

   EXHIBIT A - Coding Specimens (6)
   EXHIBIT B - Statistical Work flow Chart (6)

** SPECIAL PROJECTS DIV/SHRIEVES/bl **

7. GENERAL INFORMATION: The installation of this procedure will provide a means of verifying the coding accuracy of Statistical Information added to the Master Tab File which will be used for subsequent renewal billings. The verification will be performed on the IBM 650 and will include Straights, Transfers and Reinstatements.

8. PROCEDURE:

   a. Underwriting Services - 1st Stage

      (1) Coding Section

         (a) Present coding instructions will be followed for:
            1 Straights.
            2 Reinstatements.
            3 Money transfers.

(Page 1 of 4)

Fig. 5.2. A Standard Office Procedure. (Courtesy, The Nationwide Insurance Co.)

A statement of procedure defines the relations between functions, personnel, and physical factors of environment that are necessary for the proper execution of a project; it may specify their conditions and requirements. Such a statement may be regarded as a codification of the law of the situation as it relates to such execution. It should represent the one best method, in so far as practicable. The more it is possible to standardize functions and factors, the more this becomes practicable. However, a procedure produces results only so far as it is soundly conceived and properly applied by the individuals and groups composing the organization.

Requirements of Sound Procedure

There are, accordingly, certain requirements that should be met, in some reasonable degree, by a business procedure. They may be summarized as follows:

1. The structure of relationships between functions must be based on their complementary characteristics. The order of performance of these functions must build up the required values into a satisfactory achievement of the final objectives of the project.
2. The kind, extent, and degree in which the required performance factors and conditions should be present should be specified for maximum economy and effectiveness. A standard procedure should represent, as far as practicable, the best methods of executing the particular project.
3. The procedure should facilitate the placement of responsibility and the determination of accountability. It therefore should provide performance standards for each critical step in the procedure, or show where and how they may be obtained.
4. The attributes of good business procedure should complement the attributes of good organization structure. This is particularly true with respect to procedural flexibility, stability, and balance.
5. All procedures, whether line or staff, have their managerial and operative phases. They should be linked together properly by appropriate control procedures. It is therefore necessary to provide for the proper initiation and closure of each critical step in the completion of a project, as well as for the project as a whole.
6. The procedure should be as simple and economical as is consistent with effectiveness. A procedure that cannot be understood or applied is obviously of little value.

A primary purpose of a procedure is to facilitate the achievement of the final objectives of a project in the most effective and economical manner. It must be adequate for this purpose. Each step should advance the project logically toward these objectives. In consequence, the complementary

relationships between the successive steps should be such that the intermediate values produced by each step will contribute to the final values of the project.

Coördinated activity is also an objective of procedure. The principal factors in coördination are time and the correct order of performance of the phases of a project. These phases tend to become the specific steps in the procedure. To facilitate coördination, therefore, the procedure should state the steps to be taken in the execution of the project, their order, and usually the place of performance. When the amount of time required for each step, the number of work units that must be completed on the project, and the date when they are wanted are known, the time of starting and finishing each step can be determined.[3]

Procedure should also promote economy and effectiveness in the performance of functions, as well as facilitate their control. It therefore should specify the work content of the functions composing each step of the procedure. It must take into account requirements for the proper performance of each step, which involves determination of what human and physical factors are necessary for performance. In a manufacturing plant, for example, time-and-motion studies are commonly used to determine the work content of a step in a primary operative procedure. Information concerning performance factors may be necessary for the preparation function in control.

A control procedure is necessarily superimposed on the operative procedure for the execution of the particular project to be controlled. The closeness of control is a function of the closeness of the time of the release of authority to act to the scheduled time of action. To facilitate control, therefore, a control procedure should make provision for orders and instructions indicating the nature of the responsibility and authority that must be delegated, and for their proper release. It should enable the initiation of action at the right time through the dispatching function. An operative procedure should facilitate the making of reports showing results accomplished. These reports should indicate who is responsible for the results, their quantity and quality, where the work was done, and when. These reports should be so designed that the completion of each step in a procedure is indicated definitely. A satisfactory control of the progress of the project cannot be established otherwise. Staff units, such as the cost department, may not receive promptly the complete information that

[3] This statement applies chiefly to the control of intermittent performance. When it is continuous, as in the case of continuous manufacturing, similar information enables the determination of the rate of performance that must be maintained.

they need for their work. From this it follows that the determination of the steps of a procedure must take into account the characteristics of organization structure. Comparisons between actual and predetermined performance cannot be made accurately, of course, unless there are accurate performance standards.

A flexible procedure is one that can accommodate itself to temporarily changed conditions without causing serious loss of effectiveness. Seasonal changes, rush orders, variations in actual and forecast sales volume, unforeseen additional work involved in obtaining information for managerial purposes, and other similar contingencies are usual in many concerns. A procedure which tends to break down under such conditions unquestionably lacks flexibility.

A stable procedure is one in which fundamental changes are made only in response to basic changes in conditions governing the execution of a project. Such changes in procedure should be slow because fundamental changes in business conditions are usually slow. Procedural stability tends to be a natural by-product of careful, thorough investigation of the functions and factors involved in executing a project. The design of a stable procedure is based necessarily on sound principles and policies for the accomplishment of project objectives. It avoids the specification of detail as much as possible. It takes time for the individuals responsible for the various steps of a new procedure to grasp what is required and its significance. Training and experience are usually required also. Too rapid changes in methods tend to lower morale, because of the discouragements, difficulties, additional work, and loss of confidence in executive leadership.

A procedure should have balance in the sense that equally adequate provisions should be made for each step. An executive may overemphasize the importance of a given phase of a project. He may impose conditions that increase the amount and expense of the work required beyond what is justified by the need or amount of additional value obtained. Equipment that is unnecessarily expensive may be bought; too many and too detailed reports may be required; unnecessarily high standards of quality may be imposed. At the same time, other steps in the procedure may be underemphasized. The result is likely to be the failure of the project. For obvious reasons, a procedure should be as simple and economical as consistent with adequate effectiveness. A procedure may represent a scientific achievement, but hardly a useful business mechanism, if it is so complex that subordinate executives and operatives cannot understand and follow it effectively.

Classification of Procedure

Procedures are intended to facilitate the work of the organization, both managerial and operative. A classification of business procedures accordingly should rest on a basic classification of business functions. It is useful in the design and development of procedure, because it brings out the distinguishing differences between the various procedural types. The following classification has been set up, with these considerations in mind, to indicate the general relation between industry and company procedures:

Industry procedures
- *Organic business procedures*
  - *Managerial procedures*
    - *Operative procedures*

There are basic industries in our economy. They deal with such broad functions as manufacturing, marketing, and finance. All of them participate in the fundamental economic mission of our industrial society, a continuous increase in the material standard of living of our citizens. Each of them has a broad, basic economic mission that distinguishes it from other basic industries. There may be great differences, accordingly, between procedures for handling similar problems in different basic industries. Most industries have some inventory control problem, for example. Inventory control methods in a manufacturing industry are quite different from those in a retail marketing industry.

The methods of companies within a major division of a basic industry usually have a general similarity. Each company is competing with other companies in its division in supplying similar values to its customers. These methods cannot be similar in detail. Each company differs in some degree from the others in so far as its objectives, policies, products, processes, organization structures, and other basic factors are concerned. Most American executives are very generous in sharing management information with the executives of other companies. A team from one company may study the methods being used by a number of companies for handling some common problem. This exchange of information is practicable only because there are basic similarities between the procedures of companies within the same industry. These similarities are in part the result of common difficulties in handling similar factors in the problem.

Organic business procedures are those that are used by the organic divisions of a business organization for the performance of their functions. These are the line divisions of the organization. They are the sales, pro-

duction, and financial divisions in a manufacturing organization. Each division may have many procedures for the various phases of its work.

The work of the organization, and of each of its divisions, breaks down into managerial functions and operative functions. The procedures of each division must be developed accordingly. Our managerial procedures obviously facilitate the work of management. They therefore have to do with management's organic functions of creative planning, organizing, and controlling the activities of the organization. We shall see some of these procedures later. We have, for example, procedures for new product design and development. We have, in the field of organizing, some definite procedures for making changes in an existing plant layout on the basis of a layout plan. We have production control procedures. All the above procedures are operated usually by the production division of a manufacturing company. It will be noticed that they are being operated by certain staff organizations for the assistance of the production line organization. Staff is an evolution from line, and serves it. A managerial procedure is usually operated by a staff department for this reason.

We have seen that as a business grows its functions become differentiated from one another, more and more. The problem of coördinating the thought and action of major groups and divisions of the organization increases rapidly in importance. There is an increasing differentiation of administrative from operative management, in consequence. The larger the concern, the more it is likely that we shall find some well-developed top management procedures. We shall find also many operative management procedures. They will probably be set up in greater detail. They enable executives to solve short-range company problems, and coördinate the work that has to be done currently.

Operative procedures specify the work that operative employees should do to complete a type or kind of project. They correlate the performance of the "making" or "doing" functions composing each step of the procedure. They do so by establishing the best order of performance of the steps, as illustrated in Fig. 6. A standard procedure may state the quantitative time required for each step. It may specify for each step the facilities and conditions for best performance.

A distinction should be made between primary and secondary operative procedures. A primary operative project is one whose completion contributes directly and immediately to the accomplishment of primary service objectives. We shall assume that a quantity of parts, used in assembling a product, has been completed in accordance with product specifications. Each part should have the required utilities, which we shall call quality

attributes. These attributes will enable the part to function properly with other parts in the assembled product. If the finished product functions in accordance with specifications, the customer should be able to get from it the satisfaction of certain needs or desires, as we have advertised. The performance of a primary operative function, then, results directly in the creation of primary service values. A salesperson in a department store and a line machine operator in a factory perform such functions. A primary operative procedure is one that is set up to assure that they perform their primary functions economically and effectively.

A secondary operative procedure specifies the methods that staff operatives should use in performing their functions. The values produced by a proper performance of secondary functions may serve the line organization in accomplishing the primary mission of the company. The production line organization needs plans for a product that can be made at a profit, and still satisfy the customer. The customer buys product, not plans, however. Some staff work may aid the line in accomplishing the company's collateral objectives. The personnel department, for example, may do much work in connection with providing fringe benefits for operative employees. These benefits may satisfy the personal desires of the employees. The customer, again, does not buy fringe benefits. He buys product, even though the cost of the benefits is included in the price of the product. Collateral and secondary values are staff objectives. They are the final objectives of secondary operative projects. Staff operative procedures are set up for the accomplishment of such objectives. The steps in such procedures are performed by clerks and other staff operative personnel.

Implementation of Staff Procedures

Procedural instruments may be any physical implementation that is used directly in the execution of some step in the accomplishment of a project. This implementation consists chiefly of (a) mechanical implements, and (b) clerical instruments. Mechanical implements include any tools, mechanisms, or other factors of physical condition that perform or facilitate the performance of a procedural step. These performance factors in primary procedures include machine tools, conveying equipment and other physical implementation that are used in making the product. These factors will be examined when process planning problems such as plant layout are discussed. Mechanical implements in secondary procedures include the great variety of office equipment. This category includes the various communications devices. Such devices facilitate a fast, accurate flow of information and ideas throughout the

organization in all directions. Organizational effectiveness depends on such a flow.

Clerical instruments also implement the performance of staff functions. These instruments enter into the performance of staff operative procedures. These facilitate the manual or mechanical performance of the steps in such procedures. Clerical instruments aid clerks and office machines in so doing. A clerk-typist may type certain information on an office form. Her typewriter is an office machine. The form is a clerical instrument that probably will convey the information to another clerk. This information will enable the second clerk to perform a later step in the particular office procedure. The functions of clerical instruments are chiefly those of collecting, classifying, conveying, or recording information. The principal instruments may be classified as: (1) orders, (2) instructions, (3) returns, (4) reports, and (5) records.

Orders and Instructions

A written order is a device for effecting and facilitating the release of responsibility and authority by specifying their nature and extent and creating a record of the fact. An order may, of course, be either oral or written. In any case, it should state the objective of delegating the responsibility and authority, and should allocate them definitely. The necessity for the order should be evident, and information concerning it should be clear, concise, and reasonably complete. Good orders stimulate interest and coöperation because of their clarity, their obvious relation to the necessities of the situation, and their definite placement of responsibility.

Written instructions are devices for effecting and facilitating the transmission of information specifying the manner and conditions of work, or some phase of it. Written orders and instructions are complementary instruments which in some cases may be combined in a single instrument; but their dual functions should not be confused. Inasmuch as instructions govern performance, these also must have clarity, completeness, and accuracy. These instructions should provide a basis for decisions in all situations that may arise in connection with the execution of the particular project in so far as they can be anticipated. The language and terminology used should be easily understood by the recipient; their tone is quite as important as in the case of orders, inasmuch as these too should stimulate interest and coöperation. Instructions are a means of assuring the proper execution of a plan. The source of information they convey should be the plan; any additional data that may be necessary should be supplied by the individuals who are responsible for the development of

the plan, or for the particular phase of it concerned. Instructions based on recorded plans should promote coördination. They cannot do this, of course, unless they also have the quality of timeliness.

Orders and instructions can be given orally or in writing. These are frequently given orally when they involve only minor adjustments of a plan to meet the changed requirements of a situation. Orders and instructions may be given orally in an emergency situation where personal command and face-to-face leadership are necessary. Oral directives have certain weaknesses, however. Such directives may be poorly conceived, less complete, and less accurate than written directives. Oral directives are subject to greater distortion because of oral transmission. It may be difficult to establish what was actually said, if a controversy arises some time later, because there is no record. There are other good reasons why important directives are usually issued, or at least confirmed, in writing. This is particularly true when there is a continuous, rapid change in the company's situation, as distinguished from a temporary emergency. Such a situation tends to be characteristic of a growth industry.

A distinction should be made between technical orders and operational orders. A technical order is a release of authority that puts a plan, or some phase of it, into effect. It may authorize the modification of an existing plan. Such an order authorizes the use of specified methods and criteria under specified conditions. Technical orders are related directly to technical instructions. The two are combined frequently, which may cause some confusion and friction in line-staff relations. Technical orders may be written in a technical staff office. These orders should be issued, nevertheless, over the signature of the responsible line executive. This is the case, even though such orders do not authorize the execution of the plan, program, or project to which they relate. The release of authority to act is the function of an operational order. This distinction between technical and operational orders is important in organizing and controlling the operations of a company.

Standard Practice Instructions

A standard practice instruction is a written description of what is regarded, at the moment, as the one best method of executing a kind or type of project. It may be called in some concerns a standard office practice, standard operating procedure, or by some similar name. When approved by the proper authority, it becomes a standard of procedure and therefore falls in the general classification of standards of function. An

example is shown in Fig. 5.2.[4] Such instructions are intended to assure the continuous, orderly advance of methods of performance. These instructions may deal, of course, with either managerial or operative procedures. When properly codified, classified, and bound together, they constitute a procedural manual. Within the field of operations, it is analogous and complementary to the organization manuals in the field of organization.

The many advantages of standard practice instructions account for their increasing use. For example, by providing a detailed record of practice in permanent form these instructions reduce the work of direction for the responsible executive, thereby simplifying training problems. The danger that instructions will be lost or forgotten is minimized. Standard practice instructions counteract the common tendency to revert to former practices and work habits. Such instructions usually result in greater uniformity in the quantity and quality of work produced, because all of the people who do a given step of a procedure are following identical instructions. The ready availability of information concerning practice makes it possible for new executives and operatives to adjust themselves more easily to new conditions of work. This is a factor in morale, as well as in effectiveness. Standard practice instructions tend to deter hasty action, inasmuch as the executives who recommend and approve them place themselves definitely on record. Their intelligent use is desirable for many other reasons. Such instructions should state the standard practice with only the necessary minimum of detail, however. Otherwise, the instructions may create an inflexible condition, stifle initiative, increase costs, depress morale on lower echelons, and produce other undesirable effects.

Reports and Returns

A report may be defined as a statement of fact, or opinion, or both, that is rendered to a responsible authority. A report gives an account of certain factors, conditions, and activities. Its purpose in business is to provide the responsible authority with whatever information may be required for carrying on managerial functions.

The characteristics of reports are peculiar, to some extent, to their purposes and the conditions of their use. There are certain characteristics that are common to all good reports, however:

[4] This is obviously an example of the combination of a technical instruction with a technical order. This is usually good practice. However, there should be no violation of the principle that a staff executive should not issue orders in his own name to organizational components that are not under his command. He may issue them in the name of his line superior, of course, when so authorized.

1. The information conveyed should be accurate, adequate, and pertinent to the purpose of the report.
2. Most reports, with the exception of some research reports, must be timely to be most useful.
3. Reports should be as brief and concise as is consistent with reasonable completeness.
4. Routine periodic reports should be well designed to speed up the work of processing them, facilitate the mechanization of office work, and reduce costs.
5. Excessive writing, transcription, and duplication of copies of reports should be avoided to minimize expense.
6. The information should be arranged to save the recipient's time and facilitate his use of the information.
7. The exception principle should be applied in executive reports.

The kinds of reports that are necessary depend largely on the kind of management functions that they serve. It is frequently helpful to classify reports on the following basis for this reason:

A. Reports for purposes of creative planning
   1. Research reports
   2. Reports of proposed plans
B. Reports for control purposes
   1. Operative reports, or "returns"
   2. Executive reports
      a. Reports for operative control
      b. Reports for administrative control

Research reports are special reports, developed as a result of a special investigation of some general problem. Such reports convey information concerning the principles, factors, forces, and effects in the problem. These reports may or may not suggest the basis of a solution for it. Such information is the final objective of the research project. This information adds definitely to the company's stock of knowledge concerning the problem. The report conveys this information to those staff executives who must make technical decisions concerning its practical application. The information enters then into design or other planning projects. If the information is the result of product research, for example, and is usable, it will enter into product design, obviously. It enables such executives to understand better why certain effects develop, what improvements in the product's ability to give customer satisfaction are possible, how the design of the product can be improved accordingly, etc.

Reports of plans may or may not be based immediately on information in research reports. Plans are formulated, in many cases, on the basis of the knowledge and experience of executives, information from outside

sources, records of previous performance, etc. They may be originated by line or staff executives, or both.

Operative reports are statements of fact regarding the results achieved in the completion of a specific phase of the project concerned. These results may be stated in terms of the quantity and quality of the values produced, relative to time and expense. Operative reports may give information concerning any interferences with performance. Such reports are the returns that relate performance to control; they are important factors in the comparison function.

Operative control reports, the first subdivision of executive reports, are usually summaries of results and of any causes of interference reported on the operative returns. We feed back such information to the operative executives who are immediately in charge of project operations.[5] Such reports enable the responsible executive to carry on the function of corrective action in the control of a project at whatever organization level the work is being done. Copies of the reports may go also to the offices of major operative executives.

Administrative control reports, as a rule, summarize operative control reports by organization elements, rather than by specific projects. Such reports show the quantity, quality, and expense of the results that have been achieved by each department and division during a particular period of time. Such reports frequently lead to further creative planning and organizing, and assist in administrative control of the organization's activities. A budget report is an example of a report for administrative control purposes. It shows the totals of various items of expense incurred by each department and division during a given period, and compares them with the adjusted budget standards for these items.

Business Records

A business record may be defined as a device for the accumulation, classification, and preservation of information in a manner that will facilitate the performance of the particular business functions concerned. According to this definition, instructions or reports may become records when properly classified and filed. The principal functions of records are:

1. The accumulation of information for use in planning, organizing, and/or control.
2. The preservation of this information.

[5] It is possible to feed back operating information directly to the machine for its self-adjustment. This may be done in connection with the automation of primary operations under conditions of high-volume, continuous manufacturing. We shall see this when we look at process design.

3. The maintenance of a body of facts that will reduce the effects of forgetfulness, prejudice, emotional bias, etc., in the making of decisions.
4. The maintenance of an account of the conditions and progress of the business.

Records may be classified on several bases, such as:

A. Function
   Sales records, accounting records, personnel records, etc.
B. Characteristics of the filing device
   Book-type files, loose-leaf records, visible index records, files of original instruments, etc.
C. Time
   Permanent, temporary, historical, or current
D. Nature of the information
   Records for the purposes of creative planning, or for control

Certain characteristics and requirements are common to most records and should be considered. Among them are the following: There should be sufficient reason for the record, and the information it supplies should be used often enough to justify its regular collection and accumulation. The record should provide the necessary information for the performance of the functions concerned, arranged and classified so as to facilitate the making of significant distinctions. As far as possible, the accuracy of the record should be assured by provision for internal audit. The principles of good form design apply to records as well as to other procedural instruments; simplicity of design and economy of operation tend, of course, to go hand in hand.

Procedural Investigation, Analysis, and Design

The objective of an investigation and analysis of a business procedure is to gather information that will make possible its improvement. In a problem of procedural design, an attempt is made to determine the proper complementary relationships between functions, physical factors, and human abilities, as they enter into the completion of some kind of business project. The requirements for and the conditions governing the performance of functions at each step of the procedure also are determined. Standard practice instructions are expected to specify these requirements, conditions, and relationships.

Inasmuch as complementary relationships are concerned, an investigation of a procedure usually begins with the initiation of action at the first step, and follows through to its termination at the final step. The work involved in each step should be broken down into its elements, and a careful and complete record made of the requirements and conditions affecting

the performance of each element. To enable the analysis and evaluation of each step, standards of condition and performance are necessary; obviously these criteria must be related to the objectives of the step. Wherever practicable, the time required for each step should be recorded. Inasmuch as a procedure usually cuts across organization lines, its investigation is often preceded by an analysis of organization structure. The principal techniques used in the investigation of procedure are process or methods analysis and time and motion studies, or variants of them.

The order followed in procedural analysis tends to be the reverse of that in investigation. The economic justification of a procedure is its contribution to the achievement of the final objectives of a business project. Procedural analysis is concerned, accordingly, with the extent to which the values contributed through the operation of the procedure are commensurate with these final objectives. It is therefore logical to begin with the final step of the procedure and work back through each successive step to the initial step. The proper performance of functions at each step usually depends on the values produced by previous steps. They should produce values that, in combination with those created by succeeding steps, will result in the successful achievement of final objectives. The values produced at each step should be checked against criteria of proper quantity, quality, time, and expense. The methods used in creating them should be examined critically in the light of the criteria of good business procedure. The intent is to improve the effectiveness of each step, simplify its performance, and reduce the cost of performing it. The best way to reduce the expense of a step is to eliminate it, if it is possible to do so.

The Procedural Flow Chart

A flow chart is a device for summarizing in graphic form the principal facts and functional relationships in a procedure. This kind of chart is sometimes called a "routine" or "systems" chart. It is helpful in methods analysis. There are many types of flow charts, since they can be used either in the analysis of primary or secondary procedures.

The chart in Fig. 5.3 is one type of procedural chart. It has been called an organizational-process flow chart. This chart emphasizes the steps in a procedure and the location of responsibility for their performance. This relationship is important because every major procedure cuts across lines of responsibility and authority. The breakdown of a project into steps must take this fact into account. A flow chart should emphasize also the principal performance factors that affect the economy and effectiveness of the procedure, and the significant differences between them. The chart

in Fig. 5.3 shows the forms and other procedural instruments that are employed. The movement of each form, and its copies, is shown. There are only two ultimate destinations of each copy: a filing case or a waste basket. This chart also summarizes, for each step, certain essential information concerning such performance factors. Some of these factors are the time required to perform each operation on a standard quantity of work, the estimated or actual annual cost of performing the operation, the equivalent number of full-time employees required for the work, and the distance that the work must be moved between operations.

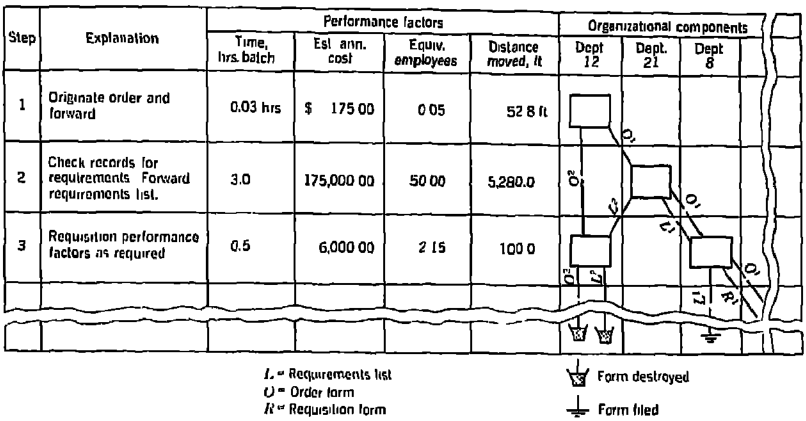


Fig. 5.3. A Procedural Flow Chart

A procedural flow chart solves nothing by itself. It merely facilitates analysis by showing graphically the general nature of the functions and factors in the particular routine, and the principal relationships between them. The chart is based on the detailed data collected previously during the study of the procedure. The analysis requires more data than can be shown on a chart. The information on the chart in Fig. 5.3 is for a hypothetical case. The relative importance of the factors in different steps has been exaggerated deliberately, to bring out the use of the chart. It is obvious that more attention should be given to means of moving the work, or of transmitting the information, in step 2 than in step 1. The work moves only 53 feet from step 1 to step 2, but it moves a mile from step 2 to step 3. The equivalent of 50 full-time employees are required for step 2, but only a fraction of one employee for step 1. The operation of step 2, furthermore, is estimated to cost us approximately $175,000.00 per year, while step 1 costs us only $175.00 per year. The company can afford to spend much more time and money on a study of the method of perform-

ing step 2 than it can on step 1. How much more? Some assumptions must be made, based on the best facts that can be obtained, before an answer to this question can be given: It will be assumed for example, that procedural improvements must pay for themselves out of savings within one year of their installation. This is required by company policy. It is the company's experience with projects of this kind that the cost of making the study cannot exceed 50 percent of the probable savings, if sufficient money is to be left for changing conditions and the purchase of new equipment that may be required. Otherwise, it may not be possible to meet the requirements of the company's policy. Previous experience with such projects also indicates that a saving of 30 percent of present operating costs for a step is probable, when the method has not been subjected previously to a thorough analysis. The staff office that will make the study has a cost of $15.00 per hour for such investigations. This cost includes a charge for the controllable expense of the office, as well as the time of the analyst. On the basis of the preceding data, an analyst could spend profitably less than two hours on step 1. This would hardly permit him to do more than pick up the obvious opportunities for improvements. It might be profitable, on the basis of the same data, to employ 3 analysts for approximately 3 months on step 2. A preliminary survey might be made to determine whether we can probably save at least 30 percent of present costs. The saving will come largely from a reduction in the number of employees required for this operation.

A final question remains: What is this staff office that will do the work? It depends on the nature of the procedure and the organizational echelon on which the work is being performed. A top management staff department handles organizational and procedural planning for the general administrative echelons in some large corporations. The office manager's organization may handle staff procedural problems at the levels of major operative management. The industrial engineer's office, if we have one, should have staff responsibility for the development and installation of primary operative procedures in the factory. It should be remembered that the executive in charge of a line department or a division is responsible for the development and use of the most effective and economical methods by his organization. Staff merely serves line in the accomplishment of its mission. The use in procedural planning of such staff offices, as we have indicated above, cannot relieve the principal executive of his responsibility for the use of good methods. It should be remembered also that in small plants the company cannot afford an extensive development of staff. The line executive must develop his own methods, or copy them

from others. He is concerned very little, in very small plants, with the development of managerial procedures. The reason is, of course, that we have very little staff. He is concerned chiefly with the development of primary operative procedures, our production methods, on the basis of his practical experience. He may be quite competent to develop such methods, initially. He may not be eventually, when his product develops and his business grows.

Management Principles and Their Use

In the beginning of this book we pointed out the vital importance of a sound management philosophy. It is vital because it provides a basis for accurate, effective thinking in the solution of business problems.

To be fundamental to all fields of business activity, the basic principles of business organization, and operation necessarily must be extremely broad and general. These principles are the basis of general policy. Because of this, the student of business who has had little practical experience may have some difficulty in evaluating their significance. As the various problems in industrial management are considered subsequently, reference will be made frequently to these principles. An attempt will be made to show wherein they are fundamental to the sound solution of these problems. There will still be many relationships that cannot be taken up because of space and time limitations. The student should make his own analyses in the light of these fundamentals for this reason. If he does this, he will find that he has developed practical and extremely valuable tools in the work of management. Basic principles, points of view, and general methods of attack will be useful long after present techniques for handling particular problems have become obsolete.

PROBLEMS

1. The Morbuy Company is preparing a policy and procedures manual. It is currently reviewing its materials management function for this purpose. Most of the materials used are standard items. Certain other materials are occasionally purchased which are not regularly carried in stock. These are generally called unclassified materials. A routine procedure for purchasing standard materials has been established and followed. No attempt has been made to set up a procedure for purchasing unclassified materials, however. The following policy has now been authorized for inclusion in the manual:

   "Buying unclassified materials involves procurement procedures of a nonroutine nature. Therefore all purchase requisitions for unclassified materials in excess of $400 must be referred to the purchasing agent for his inspection and approval. The assistant purchasing agent may approve

requisitions below this amount, provided they have also been approved by an authorized line executive."

(a) What principle of management is being applied above?

(b) In what specific ways does the above policy determine the procedure to be followed?

2. A certain manufacturing plant makes heavy machinery entirely to customer specifications. A contract may be in production for more than a year before the machine is shipped. The parts and subassemblies of the product are correspondingly large. In this plant, a job ticket is issued to a workman when he is assigned to a new job, the time of issue being stamped on the ticket. At the same time, the ticket which he turns in for the completed job is also time-stamped. At the end of the day, each man turns in his job ticket. If he has not finished his job, he receives a new ticket for the job the next morning, stamped with the time the work session starts. At the end of the day the total of the time on all job tickets for a given workman must equal the total number of hours in the work period. During the day, the shop clerk sorts the job tickets by the men's clock numbers and extends the time on each ticket. He has to complete the extensions of time on the job tickets for all the men in his department, check their job time totals, and turn in the tickets to the production control department before going home. This usually requires him to work about 15 minutes overtime. Each job ticket contains all the information necessary for cost, payroll, and production control purposes.

(a) Evaluate the shop-clerks' job-and-time reports in terms of the characteristics of any good reports.

(b) Have any of these characteristics been overlooked in this case?

3. The production control department, in the preceding case, utilizes the information on the job tickets to make up status reports. These reports show the number of hours charged against each job. Once a week, a report is compiled, showing the total number or hours completed on each job to date. A progress report is made at this time, based on the foremen's estimates of the time required to complete each job in each department. The time and cost estimates originally made for each job are also reported. These weekly reports are submitted to the division superintendent. A monthly report of the status of production is submitted to the factory manager. This report shows the number of jobs behind schedule in each department, and the extent of deviation of actual production from planned production for each contract, with the reasons therefor. Another report is made up monthly and submitted to the factory manager by the cost department. This report shows the total direct costs incurred for each department, together with a comparison of this figure with the corresponding standard costs.

(a) What are the basic differences between the daily reports made by the shop clerks to Production Control, and the weekly reports made by the latter department to the division superintendents?

(b) What are the basic differences between the weekly reports made to the division superintendents and the monthly reports made to the plant manager?

(c) How would the above reports be used in an operative control of production, under the given conditions of manufacturing? How would they be used in an administrative control of production?

4. A small local company which makes tools and special equipment for concerns in central Ohio made \$900 on one job and lost \$1400 on the next. In the first instance, there was an excessive profit, and in the second an excessive loss. In neither case were these results anticipated. In making up his quotations, the owner of the shop looked over any drawings and specifications that were submitted by the customer, estimated on the basis of his practical experience the amount of material and time that would be required for the job, and added a percentage for overhead expense and profit. In filling the order, the work was issued to the machinists and toolmakers by the shop foreman in the order he considered it should be done. At the end of the day, each workman made out a time slip stating how much time he had spent on each job. These time slips were turned in to the bookkeeper, who extended the man's time on each job at his hourly rate of pay, and entered the resulting labor costs every day in a form on the back of the shop order for the job. The foreman entered the kind and amount of material used on his copy of the shop order, and turned it in to the bookkeeper when the job was finished. The labor and material costs were then totaled on the back of the shop order and a percentage was added for overhead expense. The order was then turned over to the owner, who could thus tell how much he had made or lost on the particular job. By comparing the cost summary with the original estimate, he could also determine to some extent why he had made or lost money. These order and cost summaries were filed for use in estimating new business.

(a) Make a routine chart of this procedure. Analyze the above case to determine whether the principal phases of the comparison function are being properly executed.

(b) Have any principles of control been violated in the performance of other basic control functions?

(c) Do the methods used meet the requirements of good business procedure?

CHAPTER 6 • The Industrial Organization

The General Functions of the Industrial Organization

IT will be helpful to make a general survey of the work of the industrial organization before proceeding to a consideration of its specific problems. In so doing, we must bear in mind certain implications of the law of functional growth. While there may be a one best organization structure for a given concern at a given time under given conditions, there is no one best structural form for all concerns, even in a particular business field. A small concern may require, furthermore, only a very simple form that is predominantly a line organization. The same concern may require a very complex line-staff structure, if it grows to large size. Any discussion of the industrial organization must deal in general terms, consequently, with the principal functional groups and their general relationships with one another.

The industrial concern, like any business organization, has three primary classes of service objectives: primary, collateral, and secondary. Of these, primary service objectives must receive first consideration, but with due regard for the legitimate requirements of the other two classes. Primary objectives are those values that the public is enabled to enjoy through the purchase of the concern's goods or services. Its competitive position will suffer, unless these values are provided in the proper quantity and quality, together with satisfactory service, at a price that the public is able and willing to pay. Over a period of time, the criteria of proper service tend to be set by competition. As a concern's competitive position weakens, its gross income from sales usually declines, and with it, the ability to provide those personal values, such as dividends, salaries, wages, etc., that its owners and employees desire for themselves.

In order to achieve its service objectives satisfactorily, the industrial organization must perform properly the following functions: (1) the creation of those utilities in its goods and services that enable them to serve the public satisfactorily, (2) the distribution of these goods and

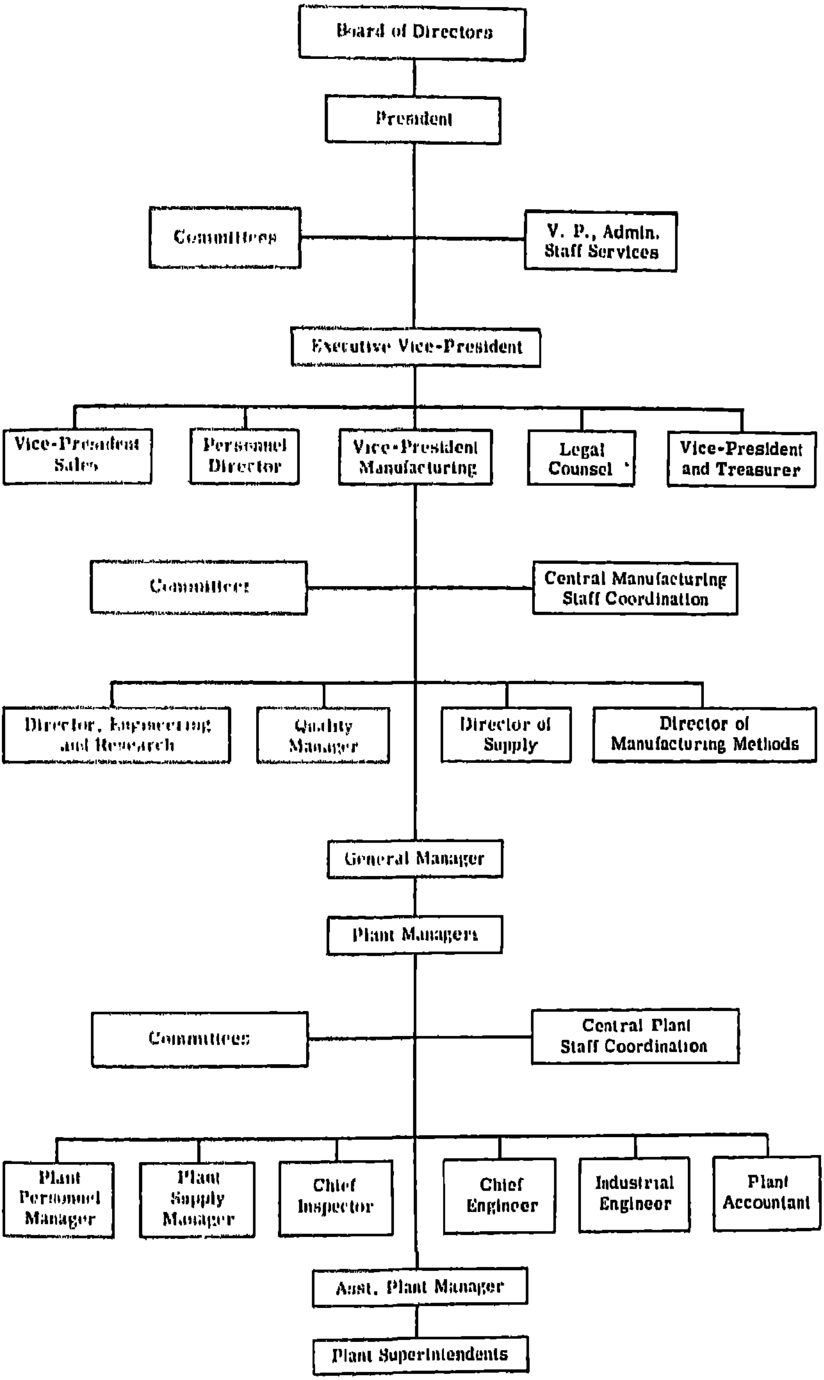


Fig. 6.1. An Industrial Organization

services to the public, and (3) provision of the capital that is necessary to carry on its economic and social functions. Thus its organic functions are production, distribution, and finance. These functions are the basis of our line divisions. All chains of command must stem from them originally. The organization shown in Fig. 6.1 is based on this concept, and emphasizes the manufacturing functions because we are interested principally in them in this book. There can be no standard practice in the structural forms of industrial organizations. Fig. 6.1 is intended merely to present graphically the major groups of functions that must be dealt with in manufacturing management. It represents a large incorporated concern engaged in multiplant operations.

The differentiation of functions in a large concern is necessarily much greater than in a small one. In consequence, many functions, that in the latter could be distinguished only with great difficulty, stand out clearly in the former. This is particularly true of many staff services. We must remember, however, that functions must be reintegrated in primary line organizations as we go down the scale of organization size, and that simplicity of structure becomes increasingly a virtue.

The Board of Directors

The board of directors represents ownership. It is a corporate element that is set up, through election, by the stockholders. All authority, both executive and operative, is delegated by the stockholders to the board through powers stated in the charter of incorporation, or through specific action taken by them in stockholders' meetings within the limits prescribed by the charter. Their right to delegate is based on the right of private property. It may be restricted under certain conditions by the state.

A board of directors may be an "inside," "outside," or "mixed" board. An "inside" board is composed of executives of the company. It is claimed to be more effective because of the greater practical familiarity of its members with the company's problems. There is the danger that an inside board may create a self-perpetuating management, through the device of the proxy. An "outside" board is composed usually of outstanding industrial, public, and other executives from other organizations than the company. Its proponents also claim that it is more effective. It has a great breadth of experience. There is little need for technical specialists in the determination of long-range general objectives and policies. The outside board is more likely to prevent dangerous inbreeding and self-indoctrination within the company's organization. A "mixed" board is claimed to

have the best features of both the "inside" and the "outside" types.

The board may appoint the various corporate officers, such as the president, secretary, and treasurer of the company. It passes on recommendations of the management that may materially alter the general objectives and policies of the company. The board may require that general plans involving the expenditures of large sums be submitted to it for approval. It may, of course, fix the salaries of the various corporate officers, determine any bonus or other incentive payments to which they are entitled, delegate to them such responsibility and authority as it deems necessary, and perform similar functions. In so doing, the board cannot exceed the powers delegated to the company by the state in the charter of incorporation, or directly by the stockholders. It obviously cannot take any action that is in violation of the laws of the state. In general, its acts must be confirmed by the stockholders. The board of directors is the fundamental policy-making body of the organization.

In large corporations, the chairman of the board may take an active part in the general management of the company's affairs. He acts for the board during the time between its meetings, and is usually assisted by an executive committee of the board. In very large corporations the board may have a number of subcommittees that are subject to call whenever important matters arise affecting general objectives, policies, and plans.

The President

The president is usually the principal administrative officer of the company. He is responsible directly to the board for the successful achievement of the organization's objectives. He has broad general responsibilities. The authority that is delegated to him must be correspondingly broad and general. His work requires high intelligence, coupled with broad general business experience rather than intensive, detailed experience in the particular business field. The larger the concern, the more this tends to be true.

The Executive Vice-President

The executive vice-president is found in many companies. He is second in command of the organization. The general division of responsibility between the president and the executive vice-president is determined largely by the president. The appointment of this vice-president and the specification of his general duties requires usually the approval of the board of directors. The general division of responsibility between the president and the executive vice-president tends to be as follows: The

president is concerned more with intermediate and long-range planning and organizing for the company's development and growth. The executive vice-president is concerned more with short-range administrative management problems. He is expected to keep the president informed of the general progress of the company in executing approved plans and programs. He may be relieved of the detail of reporting when the company has a top administrative staff executive. This executive serves both the president and the executive vice-president.

The Executive Committee

The executive committee of the company organization is usually quite distinct from the executive committee of the board. The organization's executive committee usually is composed of the heads of the principal company divisions, together with such other individuals as the president may appoint to it. The function of the committee is to facilitate planning and coördination through the pooling of the ideas of the division heads. There usually are certain problems that must be referred to it. The committee advises the president concerning the solution of the problems.

The principle of compulsory staff advice may be applied, as indicated above. Standard procedure may require division heads to submit their plans for handling certain specified types of problems to this committee before taking action. The committee may recommend, but usually it has no authority to approve or disapprove. Its recommendations acquire line authority when and as they are approved by the president.

There are usually other committees for designated special problems. They may be temporary or permanent. Too many committees are undesirable for reasons that have been noted previously.

Top Management Staff Services

A "vice-president for general administrative staff services" is shown in Fig. 6.1. The executive in charge of this function may have various titles, such as "manager of management control," or "director of management services." An "assistant to the president" may perform some of these functions in a small concern.

This top management function has had a rapid development in some large corporations since World War II. It reflects in part the necessity for relieving our top executives, both line and staff, of the great pressures under which they work. The high mortality and early retirement of these executives is ample evidence of the magnitude of these pressures. This kind of staff is expected to relieve our top line executives of as many con-

ferences and other time-consuming administrative details as possible. The intent is to give them more time for a personal leadership of their subordinates; to give them more time to sit back and think.

There is a general agreement as to the functions that should be assigned to this top administrative staff group. It should perform such duties as will correlate and facilitate the performance of general management functions at the top administrative levels of the company. This includes the levels of our top line and technical staff executives. There is no exact agreement, because of the recent rapid growth of the function. The president usually decides what duties will be assigned to this top administrative staff executive. The decision will be made probably with the concurrence of the executive vice-president, and the advice of the executive committee.

These top staff functions fall within two basic areas of administrative management; administrative planning and administrative control. The staff planning functions of this group may include organization and procedural planning for the top management levels. It maintains the general policy, organizational, and procedural manuals for the top administrative levels of the company. Its planning functions may also include economic forecasting, the coördination of thinking in the development of top management plans and policies, and the investigation of interdivisional problems in the field of top administrative management. Some functions of marketing research and new-product development have been given to this group in some concerns, because of the interdivisional nature of these problems. The staff control functions of this group may include the coördination of general administrative programs, progress reports for top management executives, coördination of interdivisional action for the removal of general interferences with program execution, and similar control duties. Statistical control and budgetary control have been assigned to this group in some concerns. Such planning and control functions may be placed under a single top staff executive. They tend to complement one another in the coördination of thought and action at the top administrative level.

This top management staff group makes use of the information and services of other staff groups, as far as possible. It should be practical in consequence for the executive in charge of administrative staff services to operate with a small, highly selected group.

The Secretary

The function of the secretary is to record the work of the board of directors and to transmit their policies to the company. In this connection,

he keeps the minutes of the directors' meetings, attends to the correspondence of the board, and handles the corporate books. In some instances, the issue of securities and the transfer of stock are handled through his office. The secretary's function is not shown in Fig. 6.1, because it is chiefly a corporate function. It is frequently combined with the function of the treasurer.

The Financial Division

The financial division of the company is concerned with the procurement of capital for the purposes of production and distribution, the conservation of this capital, and the work of management related thereto. It employs relatively few people as compared with the sales and manufacturing divisions. It represents, nevertheless, an organic function of the business. Its principal chain of command accordingly must be regarded as a primary line organization.

The chief administrative officer of this division may be the treasurer. His office usually is established by the company's bylaws. He is appointed by the board. He reports to the president in some companies. He may or may not be a member of the board of directors. The requirements of the treasurer's position are such that in a large concern it can be filled successfully only by a man of unusual business and financial ability, equipped with a thorough knowledge of corporation finance and banking practice, good business foresight, and considerable experience in the work of finance. We may have a vice-president and chief financial officer in a large corporation. The treasurer will report to this officer in such cases. This department represents a differentiation of the treasury function from the administrative management of finance.

The Comptroller

The comptroller is a staff executive. He is responsible for certain staff functions of finance that have to do with financial control of operations. He may report to the treasurer, or our chief financial officer, for this reason. He may report to a higher line executive in some concerns, because of the importance of his function in administrative control. His responsibilities may include such functions as auditing, payroll, accounting, business statistics, budgetary control, costs, and financial analysis.

The chief accountant keeps the company's financial records. He is responsible for the correct accounting of its assets, liabilities, incomes, and expenditures, and the origination of various financial reports necessary for the control of operations.

The cost department records the amounts expended for labor and material in producing the various items of the product, and distributes the indirect expense of manufacturing over them to get the cost of each item. Usually it keeps the factory indirect expense accounts. The cost records constitute the work-in-process ledgers, which should be related to the general books of the company.

The auditor is responsible for verifying the correctness of the accounts. He must examine them in sufficient detail to determine how accurately they have been kept. This means that he must go back to original sources of information and check individual entries in the books. The work requires not only a considerable knowledge of accounting, but patience, powers of analysis to determine the causes of discrepancies, and the ability to work accurately with a great mass of detailed data.

Some concerns have a statistical division headed by a chief statistician. He may report to the comptroller. There is a tendency to place the statistical function under a top administrative staff executive, as noted previously. He receives from all departments facts bearing on the conduct of the business. It is his function to treat these data statistically and to present them in a manner which will make their relations to management problems easily understood. The need for more refined and accurate data in connection with administrative planning, organizing, and controlling has given the statistician a permanent place in the larger concerns.

In an increasing number of concerns, budgets covering the various items of sales and manufacturing expense are being set up in an attempt to predict, plan, and control the expenses required for sales and production during a coming period. The expenses of departments are checked periodically against their budgets to determine how well they are keeping within them. The head of the budget department is frequently called the budget director. Budgetary control is obviously a phase of the comparison function in administrative control.

The Office Manager

The office manager is primarily a technical staff executive. He supplies various services that facilitate the performance of office work. He may also aid in expediting and coördinating the flow of clerical work through the organization. He should have staff responsibility for the design and installation of staff operative procedures. He is usually responsible for the mailing and messenger service, various intercommunication services, the central filing section, the central stenographic section, and similar office groups. He reports, in some concerns, to the secretary of the company.

He reports to the comptroller or the chief financial officer in other concerns. The financial division generates a large amount of clerical work. The office manager has been placed under the chief financial officer, in Chapter 30, for administrative purposes.

The Credit Department

The use of credit is a major factor in the distribution of manufactured goods in many industries. The expansion of sales, through judicious extensions of credit, while keeping credit losses at an economic minimum, is a difficult problem.

The place of the credit function in the industrial organization is controversial. Some authorities prefer to place credit and collections under the financial division. The credit manager may report to the chief financial officer in such case. The desire to reduce bad debts may result in the refusal of credit to concerns whose prospects warrant its extension, when credits and collections are under a financial executive. The chief financial officer may point out, however, that an increasing collection period may require increasing use of the company's credit. He may have other reasons why he believes that credit and collections are financial functions. The desire to get and hold business may result in too liberal extensions of credit, when the credit and collections function is under the sales manager. We may have a weak collection policy, because of a reluctance to lose customers. Some credit experts feel that a proper balance between these opposing tendencies will be struck when the credit manager's functions are differentiated completely from both the sales and the financial functions. The final decision will be made probably by the company's chief executive, in the event of a difference of opinion between the heads of two primary divisions that they are unable to resolve between themselves. Credit terms are an important condition of sale for many manufactured products. The granting of credit is regarded here as a staff function of marketing. The reasons for this decision will be noted in Chapter 7. The credit manager reports directly to the vice-president in charge of marketing and sales in Fig. 7.1. He is on the same echelon with the sales manager, in this position. Credit policies and procedures that affect the work of the financial division must be coördinated with that division.

The Marketing Division

The marketing and sales division is responsible for the proper performance of the distribution function. It is a primary division, because

distribution is an organic function in a manufacturing concern. The line organization of the marketing division must be regarded as a primary chain of command. In a large company it may extend from a vice-president in charge of the division, through a sales manager, territorial managers, zone managers, and district managers, to the salesmen in the field. All other elements of the sales division are staff units, with the possible exception of advertising. As a rule, the principal staff functions are marketing research, sales promotion, sales planning, sales analysis, credits and collections, and certain others that have to do with the operation of a headquarters sales office. The objectives of the marketing division are a satisfactory volume of sales for the various products of the company, a reasonable cost of distribution, a line of products or services that will anticipate and meet the changing needs and desires of the public at competitive prices, additional territories and product lines that will make possible an increasing sales volume, and other values that must be secured if the concern is to meet its economic objectives properly.

The Manufacturing Division

The manufacturing division represents structurally the organic function of production. It is responsible for the manufacture of products of the requisite quality, in quantities sufficient to meet the sales demand promptly at a cost that will permit the company to compete profitably. In achieving its service objectives, the manufacturing division must exercise due consideration for the personal objectives of its executive and operative personnel. It is usually the largest division of the industrial concern on the basis of numbers. Its line organization is a primary chain of command. This chain extends in Fig. 6.1 from the president and executive vice-president, through the head of the manufacturing division, the general manager, the various plant managers, superintendents, general foremen, foremen, and assistant foremen, to the operative employees in each plant. The principal technical staff functions serving the line function of production are usually product and process design, quality control, materials and supply, and personnel.

The head of the manufacturing division should possess great organizing and leadership abilities. He should have a broad knowledge of manufacturing. A detailed knowledge of the processes carried on by his division is less essential. This is particularly true in large companies because he cannot be personally familiar with all the operations of his division. This executive must be able to organize and work through his line and staff

subordinates. He may be assisted by such committees as may be helpful in integrating the activities of his headquarters offices. A divisional executive committee may be one of them. The manufacturing executive may have a small central staff coördination group. It performs services for the manufacturing division that are similar to those performed by the general administrative staff services group under the president.

The general manager is found frequently in companies engaged in multiplant operations. He is a line executive. This executive has usually the immediate responsibility for the operation of the company's plants. The various plant managers report directly to him, in consequence. The general manager is usually the second in command of the manufacturing division, because of this key position. The various staff departments in division headquarters must serve the general manager as well as the vice-president for manufacturing.

The Plant Manager

The company shown in Fig. 6.1 must be large to support multiplant operations. It is probable that its management is highly decentralized. Each plant has its objectives for a coming period. They are specified definitely in terms of the quantity and quality of product that must be shipped during the coming period, and the allowable plant operating expense. Each plant is regarded as a "profit center." Each plant manager is expected to operate his plant at a profit. Complete responsibility and authority for plant operations are delegated to him accordingly. His decisions are subject to administrative direction and supervision by the general manager, of course. The intent is to hold the plant manager completely accountable for results. Any limitations of his responsibility and authority are necessarily broad. This is one reason why the plant manager's staff may parallel the headquarters staff of the manufacturing division. It should not duplicate its work, of course. Another reason for staff parallelism may be the geographical dispersion of plants. There are other reasons.

The plant manager may set up various plant committees, including a plant executive committee. The central plant coördination group, shown in Fig. 6.1, deals largely with the central control of plant production. There may also be production control groups on lower levels of the plant organization. We shall see them when we look at the problem of production control.

The head of a plant organization may have a number of titles, in addition to plant manager. He may be known as the factory manager, works manager, or by some similar title.

Product Design Functions

The product is the vehicle that conveys to the public certain values. The determination of the characteristics that the product should have, if it is to satisfy the needs of the public properly, involves creative planning. As the product develops and the business grows, product designing becomes increasingly complex. It requires more and more a specialized training, background, and experience. Because of the obvious need for specialization, certain phases of the work usually are differentiated from the line function of production early in the growth of the concern. The ultimate result is the development of a technical staff department that is responsible for the creative planning of product. The product design function, in the organization shown in Fig. 6.1, has developed at least to the fifth stage of staff evolution. This is the stage of staff elevation. This company has a director of engineering and research. His problem is to coördinate the work of research, product development, and design for the company as a whole. The director provides a leadership of ideas in these fields. He reports usually to the vice-president for manufacturing, under these conditions.

Large manufacturing concerns have frequently a well-developed research organization. It will be seen later that they spend large sums of money on research. Product research can make important contributions to effective quality competition. Process research can contribute greatly to cost reduction, and therefore to effective price competition. It is therefore probable that the research function in Fig. 6.1, has been differentiated completely from product and process design.

It will be seen that provision for a chief engineer in each plant organization has been made. This implies that decentralization has been based on some form of product specialization. Each plant may have the responsibility for the manufacture and sale of a certain style, type, or quality of product. The automobile industry uses all the forms of line specialization that are shown in Fig. 4.2.

While some such staff function may be required by any large manufacturing organization, its characteristics may vary greatly in different manufacturing fields. If the concern is making a mechanical product, such as an automobile, the creative planning of the product may be based on mechanical or electrical engineering. If it is a chemical product, it may be based on chemistry and chemical engineering. If it is a nonmechanical or nonchemical product, such as clothing, shoes, etc., it may be based on the

aesthetics of design. But regardless of its basis, its proper performance affects competitive success to a great extent.

Process Design Functions

The objectives of process design are economical and effective manufacturing conditions and methods. They should enable us to make a product of specified quality in the quantities that are required to meet the forecast customer demand. They should enable us to do so at a cost that will permit us to meet competitive prices and still make a reasonable profit. The planning of manufacturing methods involves many difficult problems. Solutions for these problems also require a specialized background, training, and experience.

Process design is obviously a technical staff function. It is related to product design. There are some basic similarities between the training and experience required by each function for successful performance. Product design and process design tend to be complementary rather than similar functions, nevertheless. The evolution of a staff organization for the creative planning of process has been, consequently, a logical result of the development of large-scale manufacturing. The title and organizational position of the head of this organization will depend on the size of the company. It will depend also on the type and kind of industry and manufacturing. The company in Fig. 6.1 has a director of manufacturing methods, who is on the same level of administrative management with the director of engineering and research. The manufacturing methods director performs the same type of headquarters technical staff services, but in the field of manufacturing methods.

The industrial engineer in the plant manager's organization has a staff responsibility for the manufacturing methods functions at the plant level. These process design functions would include operation layout, work routing, selection and modification of capital equipment. They would include the development of automation, tool design, plant layout, the solution of materials handling problems. They would deal with the determination of production and other process standards. The industrial engineer performs other manufacturing methods functions for the line organization of the manufacturing division. Certain plant engineering functions may also be assigned to him in some organizations. These functions may include such work as power production and distribution, plant maintenance, and plant construction. The title of industrial engineer is used in many plants to designate the staff executive who is in charge of the plant process design functions. There are other titles that may be

used; we shall note some of them later, when we look further at the process design functions.

The Function of Quality Control

The utility of a product or service is its ability to satisfy a need or desire. The creation and distribution of utilities are affected basically by the factors of time, place, form, and possession. Quality may be any combination of characteristics, such as dimension, finish, etc., that give a product the required utilities. Quality objectives are of prime importance, since quality competition affects greatly the operations of most industrial concerns.

The development of a product necessarily involves the increasing refinement of its quality attributes, and the improvement of their relations with one another. Close, accurate control of the kind, degree, and condition of these attributes becomes more and more necessary. The control of quality may also become a complex problem requiring some specialized training, background, and experience. It should be regarded as a technical staff function, for reasons that will be apparent shortly.

Responsibility for producing goods of the requisite quality falls primarily on the line organization of the production division, and should remain there. In small concerns this division frequently must carry on all the functions involved in the production of goods of the required quality and quantity. As the product develops and the business grows, a technical staff department for quality control develops gradually. This department is responsible for an accurate determination of the degree of quality that has been produced, not for the actual production of quality itself. It renders certain services of technical comparison that facilitate the control of quality by the line organization.

The function of quality control breaks down into certain distinct subfunctions or phases. The principal phases have to do with inspection, the maintenance of inspection accuracy by the periodic check of inspection instruments, statistical quality control, the analysis of special quality problems, and the function of records and reports. These phases furnish the basis for the organization of the work of quality control.

This function is headed, for the company in Fig. 6.1, by a quality manager. He performs for his field the basic functions of any headquarters staff executive. The quality manager is concerned primarily with the coördination of thinking between the production line organization, and other staff groups, in the solution of quality problems. Some of these organizations are engineering, manufacturing methods, purchasing, and

personnel. Company-wide problems only should be considered at the quality manager's level. The chief inspector is responsible for the quality control function at the plant level. He may have under his command a large force of inspectors and other personnel. These people check the quality attributes of the product against quality standards, apply statistical quality control techniques, check the accuracy of gauges and other quality control instruments and methods, coöperate with line personnel in correcting quality deviations, and perform similar quality control duties. The chief inspector and his subordinates are not responsible for producing quality. He is responsible for determining accurately the quality of the work produced. He may be responsible for assuring that no subquality product is shipped to the customer.

The Materials Supply Functions

Any manufacturing concern must perform certain functions of procuring, storing, and releasing materials for directly productive and other purposes. As we go up the scale of organization size, these functions also respond to the operations of the law of functional growth. Various supply functions begin to be differentiated from the primary chains of command, first distinctly and then completely. In large concerns these functions may be integrated finally in a major staff organization known as a materials procurement or supply division. This division usually assists in planning the materials requirements of the manufacturing division. The great bulk of its work, however, has to do with rendering various facilitative services in connection with supply. Its objectives are the right quantities of the right materials at the lowest cost consistent with the required quality, together with delivery at the right time and place. It is concerned with inventory turnover, adequate coverage of requirements, price protection, and similar economic problems.

The head of the supply division may be known as the director of procurement and supply, materials manager, general purchasing agent, or by a similar title. This executive is a technical staff specialist in the field of supply. He should have an expert knowledge of its functions, the factors affecting them, and the best current practices. For example, the director should be thoroughly familiar with modern methods of storing, handling, and releasing materials. He should understand the problem of salvaging waste and scrap materials. The supply director should be capable of integrating purchasing power through standardization and other means. He should be able to apply an effective administrative control of inventories, etc. This executive should be sufficiently familiar with produc-

tion control methods to permit him to coöperate intelligently with the production division. In a large organization, several departments representing the principal phases of the supply function may report directly to the materials manager. The more common are the purchasing, stores, receiving, shipping, salvage, and traffic departments. He may be responsible in some cases, for the operation of an internal transportation system. Quite frequently the director is ex-officio chairman of a materials committee that assists in the standardization of materials and the planning of inventories. In small organizations, some of these functions must be integrated in the interests of economy.

The exact structural form of the division will depend principally on the size of the concern. It will depend also on the characteristics and requirements of the company's supply problems, and the views of higher administrative executives. The supply function is headed by a director of supply, in the company shown in Fig. 6.1. He is concerned primarily with plans and policies concerning procurement and inventories, for the company as a whole. The director provides the plants with the basic headquarters services, as they have to do with supply. He may report to the executive vice-president, when the importance of materials cost and supply problems warrant it. The supply function at the plant level is headed by a supply manager. He may be called the plant materials manager, or the plant purchasing agent, in some other company. This manager may be responsible for local buying for local needs, plant receiving and shipping, the operation of plant warehouses and storerooms, and other plant materials functions.

The Personnel Division

The personnel division is a technical staff organization. It has two principal functions: the procurement, selection, and maintenance of the organization's personnel; and the development and maintenance of morale. Of course, the background, training, and experience required for personnel functions are quite different from those for other technical staff groups. The status of the executive in charge of the department varies greatly between different industries, with the size and character of the business, and with the progressiveness of the company's top leadership. It varies with the general state of morale in the company, the community, and the industry. It depends also on the importance of labor costs in the prime costs of operations. A company whose processes are highly automatic could have a labor cost that is no more than 10% of its prime cost. Such a concern could afford better to grant wage increases and

fringe benefits than one in which labor is 90% and material is 10% of prime cost. The first company can, in effect, buy term insurance against work stoppages or other cost-increasing practices. It cannot buy good morale, however. A top management with a cash-and-carry personnel policy might feel, mistakenly, that it does not need a superior staff leadership in the field of personnel and industrial relations. This is not the case, evidently, in the company shown in Fig. 6.1. It has a director of personnel and labor relations who reports directly to the executive vice-president. This executive might report properly to the manufacturing vice-president, in another concern. The company in Fig. 6.1 also has a personnel manager at each plant. These executives have staff responsibilities at the company and plant levels, respectively, for such functions as employment, wage and salary administration, employee health and safety, education, and training, employee service including the administration of various employee fringe benefit plans, and labor relations. The director of personnel and labor relations participates in labor contract negotiations.

The personnel executive should possess sympathy and an understanding of the worker's point of view, inasmuch as he is dealing primarily with human rather than mechanical forces. He must have tact, personality, and the ability to win the confidence of the employees. In addition to the social phases of his work, there are business and managerial phases which are equally important, and for which he must have business acumen. In connection with the company's manufacturing program, he should anticipate the necessity for increasing or decreasing the working force. In many instances this requires some analysis of the relation of employment and the general business cycle to the company's business cycle. The personnel manager should have sufficient knowledge of manufacturing methods and problems to enable him to judge the effects of proposed personnel methods on the concern. Personnel policies and techniques have been developed and improved to the point where specialized training is required. The background for this training is chiefly in the social rather than the physical sciences, however.

Line-Staff Relationships

It should be noted in Fig. 6.1 that most of the staff departments and divisions which report to higher line executives are primary technical staff. They are concerned chiefly with problems of planning or technical facilitation for their particular fields of specialization. Each one deals largely with certain primary factors affecting the performance

of primary operative functions. The scope of their responsibilities depends on the echelon on which they serve.

Important coördinative staff functions are being performed by the staff service groups in Fig. 6.1. They are concerned with coördination problems at the echelon on which they serve. These staff service groups also perform certain secondary technical staff services, as noted previously. It is important to note that these services deal largely with certain factors in the performance of managerial functions, rather than primary operative functions.

Both coördinative and technical staff functions may be performed concurrently at the company and the plant level. In a large corporation, we may have parallel performance of staff functions at the corporate, corporate divisional, company, company divisional, and plant levels. The result may be some difficult problems in line-staff relations.

There are many organizational principles that may enter into the solution of these problems. They can be found in books on top administrative management. The following are only a few of them. They are intended chiefly to clarify the nature of these problems:

1. *Unity of Command.* "For any action whatsoever, an employee should receive orders from one superior only."[1] Otherwise, there is danger of conflicts of authority, friction, indecision or improper initiative, buck-passing, compromises based on personal rather than organizational objectives, deterioration of morale, and other organizational difficulties. It is likely that these difficulties will develop, even though there are significant differences between the authorities of the executives from whom the individual must take orders.

2. *Staff Release of Orders.* Orders and instructions, either technical or operational, may be prepared for line execution by a staff officer. They should be released over the signature of the line superior to whom the staff officer and the line group report. Otherwise, there is danger of a violation of the principle of unity of command.

3. *Staff Parallelism.* A similar grouping of similar staff functions on adjoining echelons facilitates coöperation and effective communications. It is likely, for example, that the personnel director in Fig. 6.1 has a training director on his staff. He is an expert probably on industrial training problems. The plant personnel manager may also have a plant training supervisor on his staff. The plant training director could and

[1] Henri Fayol, *General and Industrial Management*, Pitman Publishing Corporation, 1949, p. 24.

would communicate directly with the headquarters training director, if he encountered a training problem that is beyond his ability to handle because of its magnitude, scope, or difficulty. This quick, direct communication of information and ideas is good. A number of difficulties may develop, however. Staff executives at every level, for example, may fail to distinguish between a channel of communication and a chain of command. Technical information that is received at a subordinate level, directly from a headquarters staff office, tends to become a technical order. The result may be an unwitting violation of unity of command. Staff or line at the plant level may attempt to shift responsibility for its errors to headquarters staff. The result, in effect, may be some unofficial recentralization of responsibility and authority. A staff executive at the operative level may feel that his personal interests are more closely related to the headquarters staff group with which he is associated than they are to the line organization to which he is attached. This may cause some line-staff friction. There are other difficulties that may result from staff parallelism. The development of effective decentralization depends on such parallelism, nevertheless.

4. *Headquarters Staff Functions.* Headquarters staff services are necessary for the effective operation of a decentralized organization. Such staff functions are located on the administrative levels of a corporation or a major subdivision of it. Headquarters staff departments perform, at these levels, certain functions that have to do with the coördination of thought and action. Such a department may act as a clearing house for new ideas within its field of specialization, make company-wide studies of problems in its field as directed, provide a consulting service for corresponding groups on lower echelons, evaluate compliance with administrative policies and technical directives, and perform similar functions. A headquarters staff executive has no rights of command over corresponding staff groups on lower levels, nevertheless. A headquarters staff department should not perform duties that corresponding staff groups on lower echelons can perform for themselves. It should confine its attention to problems in its field at its administrative level. The difficulty is that some headquarters staff executives are congenital operators. They get into problems that are not their concern, because they do not understand the difference between administrative and operative staff work.

5. *Limitation of Staff Economy.* Staff serves line. It is usually necessary for staff functions to operate with something less than maximum economy in order that primary line functions may operate with maximum economy and effectiveness. It is better, for example, to have maintenance

mechanics idle, when there are no mechanical interferences with production, than to have line operatives and capital equipment idle when we have a major machine breakdown. We get our money from the customer. We shall not have maintenance operatives idle, of course, if we can find other work for them. The cost of staff operations is overhead expense. The difficulty is in maintaining economical but adequate staff-line man power and expense ratios for our staff departments.

6. *Effective Use of Staff Service.* Some line executives have a tendency to formulate and activate their plans without coördinating with the staff executives who have a professional interest in the particular problem. The company is paying for technical staff service that it does not get, to the extent that this happens. There is a principle of compulsory staff advice that is very old. It says: No decision on an important problem should be rendered, or action taken by the responsible executive, until all have been heard who may be able to contribute significantly to its solution. It is frequently specified in a standard procedure that a designated staff office must be notified when a problem covered by the procedure has developed to a certain stage.

And so the story goes. There are other problems of line-staff relations. There are other principles also that govern the effective use of staff. The moral of the story, if any, is that there can be no perfect organization, because the human race is far from perfect.

Large- and Small-Scale Operations

It is helpful to examine management functions in large plants. These functions are greatly magnified. They therefore can be studied in greater detail. The same basic functions are present in small plants, of course. They must be combined in the interests of economy, however. An executive in a large plant may be in charge of a department which performs a single function. The same executive in a small plant may be responsible for a number of functions. It may be difficult, in consequence, to distinquish clearly the different management functions. Yet it is equally important that adequate provision for their proper performance be made. The fact that small-plant management mechanisms are simpler is not particularly important. It is always desirable to develop organization structure and procedure in the minimum degree that is necessary for competitive economy and effectiveness.

PROBLEMS

1. A small company in the metal-working field employs about 55 operative employees. Its production division consists of 5 departments, each under a separate supervisor. These supervisors report directly to the owner-manager.

In addition to exercising general control over production, the manager also makes decisions on matters of credit extension to customers and arranges for obtaining credit from vendors. He makes the arrangements personally for obtaining working capital. The general sales manager has complete responsibility for sales policies and functions.

A purchasing agent spends approximately 80% of his time in purchasing materials. He also helps the manager to plan the sequence in which orders will be processed in the production division. In addition he assists in determining tooling requirements for the various orders. He helps the production supervisors determine the operations to be followed and the equipment to be used.

A quality control manager has the responsibility for all inspection and maintains records of quality of output. He has the additional duty of compiling records of progress made on all jobs at the end of the day. He submits this record to the general manager.

An accountant performs all the accounting work, including the compiling of cost reports for the general manager. He supervises two female clerks in the accounting section. He also supervises the receptionist and switchboard operator.

(a) Which major staff functions have not yet been differentiated in this organization? What additional information would you need to enable you to determine whether these functions are important in this business?

(b) This company is small, but it is growing rapidly. How could a job analysis technique be helpful in determining approximately when and in what degree these staff functions should be differentiated?

(c) What can a small company do to maintain its competitive effectiveness against large concerns in its industry, when it cannot afford to set up a needed staff service to the extent that is required?

(d) What organizational changes might be helpful to this company at this time? It is understood that your suggestions are subject to verification by a subsequent survey of the organization.

CHAPTER 7 •

• The Marketing of Manufactured Goods

The Marketing Function in Industry

IT was noted in Chapter 2 that the line divisions of a business organization devolve from its organic business functions. In a manufacturing organization, they are the functions of production, distribution, and finance. The marketing functions in industry may be defined as any business activities that enter directly into the distribution of the goods or services of an industrial organization to its customers.[1] The work of the marketing division of a manufacturing concern has to do with the performance of such marketing functions as may be assigned to it by the company's top administrative executives.

Objectives of the Sales Division

The work of an organization is necessary because of certain objectives that must be accomplished. An objective is a value for which someone is willing to make the effort or sacrifice that is required to get it. A value may be any satisfaction of a need or desire. It may be tangible or intangible. The primary objectives of the business organization are those economic values with which the company serves its customers. Profits, salaries, wages, and other personal benefits of owners or employees are collateral objectives. A profit, for example, is merely an academic notion until we get the customer's dollar. The general reasons why this is so have been discussed previously. The economic utility of an article is its ability to satisfy certain customer needs or desires, as required. This ability is conditioned by the factors of time, place, form, and possession. These factors affect all the organic manufacturing functions. The work of the sales division is affected particularly by the factors of time, place, and posses-

[1] The following is a broader definition of the marketing function: "Marketing covers all business activities necessary to effect transfers in the ownership of goods, and to provide for their physical distribution." H. H. Maynard and T. N. Beckman, *The Principles of Marketing*, The Ronald Press Company, 1952, p. 3.

sion. It follows that the work of the sales division has to do chiefly with getting into the hands of the customer whatever goods or services are wanted, when and where they are wanted, and at a price that he is willing to pay.

There are necessarily certain requirements for effective accomplishment of any economic objective. These requirements can be expressed in terms of quantity, quality, and expense, relative to time. A performance standard is frequently a specification of an objective in terms of these requirements. The quantity requirement for a sales organization, or a line component of it, may be expressed in terms of the dollar or physical volume of sales that is expected during a coming month, quarter, or other time period. The volume that may be expected depends on the sales potential for each of our products in each of the sales territories in which the company operates.[2] This volume represents the quantity of certain customer satisfactions that we can expect to supply, based on our expected proportion of customer demand for each product. We may expect, for example, to sell 100,000 units of our line of X gadgets in territory Y, during the coming quarter, at an average unit price of $5.00 per gadget. It is obvious that we shall get a half-million dollars worth of business out of the territory, if we do. The volume requirement is an important consideration in many marketing problems, such as expansion into new territories, budget appropriations for advertising and sales promotion, development of sales organization structure, and others.

The quality of a product is that combination of characteristic attributes which enables it to give customer satisfactions, and distinguishes it from similar products. Quality attributes may be any product characteristics in whatever combination will enable the product to accomplish its mission of customer satisfaction. We shall see later that sound is a quality characteristic in a room air conditioner. It is unlikely that the customer will get the satisfaction of a good night's sleep with a collection of nuts and bolts rattling around in his room, regardless of the levels of temperature and humidity that may be maintained. A sound level, in terms of decibels, is specified by the manufacturer's engineering organization. The sound produced by the operation of a room air conditioner must not exceed the specified level. An inspector, working under the chief inspector in Fig. 6.1, will reject the particular piece of equipment if it does. It is evident that the quality requirements of a product set up certain engineer-

[2] Marketing experts usually define the term "sales potential" as that proportion of the total market for a type of product that the company's product may expect to get. We shall see shortly some of the factors that affect it when we look at the work of marketing research.

ing and production requirements for the company's manufacturing division. They set up also certain requirements for its finance division. Quality requirements usually condition substantially the type of manufacturing in which we must engage, and therefore our capital requirements. The reasons why this is so will be seen later. It is sufficient to note here that close coöperation between the major divisions of the business, both line and staff, is necessary for an effective, economical accomplishment of the company's quality objectives. This coöperation involves more than coöperation with production and research organizations in new product development. Such development is highly important, of course, because of its relation to quality competition. This is a more difficult form of competition, in many ways, than price competition. Anyone can cut a price in desperation, or without regard for the long-run effects on the economic health of the company. It requires superior manufacturing brains and ability to develop products and processes that will give the customer better value at the same or a lower price, with the same or a better profit margin. It should be recognized that advertising can give prestige to some products. Prestige is a value, since it satisfies a desire of some people. Advertising can enhance other product utilities. It should be recognized also that price, quality, and sales volume are interacting forces. There is a relationship between them that is usually difficult to determine.[3] There is, nevertheless, a "principle of uniquity" that can be stated as follows: a unique contribution of customer service by a product improves its competitive position, reduces the force of price competition against it, and facilitates the maintenance of a satisfactory profit margin.[4]

There is a direct relation between expense requirements and sales objectives. Distribution costs have received wide discussion. They are greater than production costs in some companies. A profit is largely the difference between net income from sales and total business expenses. Distribution costs accordingly are of great interest to top management. The responsibility for cost reduction falls immediately on the executive who has the authority to make the expenditures. This executive is the head of the sales division in this instance, our vice-president for sales in

[3] Joel Dean says: "The heart of the difficulty is that the setting for analysis, i.e., other determinants of demand, changes too rapidly to produce an adequately homogeneous set of data." *Managerial Economics*, Prentice-Hall, Inc., 1951, p. 178.

[4] D. M. Phelps thinks that: "In recent years, certain manufacturers have relied more and more upon product development and apparently less on production economies to keep ahead of competition." *Planning the Product*, Richard D. Irwin, 1947, p. 17. (It is probable that many production executives and industrial engineers would question that there has been less reliance on production economies, judging from the pressure from top management for cost reduction.)

Fig. 6.1. He may make use of any staff anywhere that is available to him, but the responsibility for cost reduction still rests on him. There are many categories of marketing expense. An analysis of them is far beyond the limits of this discussion. It may be sufficient to note that the cost per call of personal selling alone is quite substantial. This cost will vary with the industry, the company, the quality of management, and the product.[5] It is significant, from an organizational viewpoint, that it leads to the planning and control of salesmen's activities. There are many other factors that affect the relations between profits and sales costs. Excess variety in our product lines may be one of them. There is the familiar example in which an excessive profit on 20 percent of our line is necessary to carry 80 percent of our line which is sold at a loss. It may be necessary, however, to have a "full line" to meet competition and give the customer a complete service. It is possible also to pass the point of diminishing returns on sales and advertising expense. This would be the point where the last increment of new business does not produce a profit that is equal to the last "dosage" of expense, as the economist would express it. There are many other problems of marketing expense. A discussion of them belongs properly in marketing texts, rather than here.

The time requirement is less pressing when we have a seller's market. This is usually the case when we have a condition of inflation and rising prices. Our plants may be loaded to capacity, and we may be operating on a three-shift basis. We have full employment temporarily. It is true that we have sales programs which specify the sales volume for each product. The sales division is expected to produce this volume, but we are in an era of easy selling. A few sales executives may become a bit arrogant, very foolishly, conducting their operations on a take-it-or-leave-it basis. The time comes eventually when we enter a period of readjustment, softening prices, and hard selling. Competition is keen. Purchasing agents are paring their inventories to release working capital, cut inventory losses, and increase inventory turnovers. They can insist on delivery when and where wanted. The buyer is in a position to cancel his order, and place it elsewhere, if the goods purchased are not delivered as promised. Close coördination and coöperation between a sales control group in the sales division and various production control groups in the manufacturing division becomes mandatory. Poor production control organization and procedure in the manufacturing division can handicap

[5] A survey of 87 industrial sales managers, made by *Printers' Ink*, was reported in the *Bulletin of the National Association of Purchasing Agents*, February 25, 1953. It showed that the cost per salesman's call rose from an average of $9.02 in 1942 to $16.31 in 1952.

seriously the work of the sales division. Time is also a factor in the planning and control of sales activities with respect to seasonal changes in customer demand, and in other ways.

The objectives of the sales division are derived from the general objectives of the company, and must be in consonance with them. A definite determination of these objectives is necessary. They are the starting points for our thinking concerning problems of sales organization and management. The thinking of our sales executives concerning many of the above problems must be coördinated, through a top management staff group, with the thinking of responsible executives in other company divisions. This is necessary because of the organic nature of the distribution function. The determination of these objectives, in consequence, affects and must precede the solution of many problems of production and financial management.

The Nature of Manufactured Goods

The product is the vehicle that conveys certain utilities to the customer. These utilities enable him to enjoy certain satisfactions of his needs or desires. The product must be sold to him at a price that he is willing and able to pay. He can be induced to buy more than he might otherwise, and to pay a higher unit price, by means of advertising, installment buying, and other devices. It is difficult by any means to induce the customer to buy a product that has no value for him. The service objectives of the product are the starting point for product design, process design, standardization, procurement, and many other problems of industrial management. We are interested, accordingly, in the nature of manufactured goods and their design. The problem of design must be reserved for a discussion later of the engineering functions.

Marketing authorities classify goods as consumer goods and industrial goods. Consumer goods are "those that are destined for use by the ultimate consumer and which are in such form that they can be used by him without further commercial processing."[6] Industrial goods may be defined as "those used in making other goods, in rendering services, or in conducting an enterprise—."[7] These goods may be broken down into subclasses, of course. The authorities begin to disagree at this point. One well-known authority offers a classification of economic goods, which is reproduced partially below.[8]

[6] R. S. Alexander, in *Marketing by Manufacturers*, C. F. Phillips, ed., Richard D. Irwin, Inc., 1950, p. 18.
[7] *Ibid.*, p. 18.
[8] H. H. Maynard, and T. N. Beckman, *op. cit.*, p. 30.

I. *Consumer Goods*
  a. Agricultural products
  b. Products of other extractive industries
  c. Manufactured goods
    1. Convenience goods
    2. Shopping goods
    3. Speciality goods
II. *Industrial Goods*
  a. Agricultural products
  b. Products of other extractive industries
  c. Manufactured goods

It will be seen that a manufacturer may produce consumer goods, industrial goods, or both. It is possible for a manufactured product to be both a consumer and an industrial good. General Electric and Westinghouse are examples of manufacturers in the field of electrical products who make both consumer and industrial goods. We have vertical economic integration in some industries. Steel companies, for example, may own and operate their own coal or iron mines, operating through subsidiary companies. Food processing concerns may own and operate agricultural facilities. A manufacturing company can produce, in other words, agricultural products and the products of extractive industries, as well as manufactured goods. When it does so, it is usually for the company's own use in its manufacturing processes, rather than for direct sale to its customers. The manufacturer can carry vertical integration to the point of company-owned and operated chains of retail stores, if he chooses to do so. He may not, since it may not be economical. Manufactured industrial goods are sold largely to industrial purchasing agents of other manufacturing concerns, transportation companies, and public utilities. They may also be sold to wholesale and retail establishments. They are bought for use by the establishment, rather than for resale and use by the ultimate consumer. Such goods include machinery and equipment, purchased parts and assemblies, and various supplies that are necessary for the operation of a business. We shall see also, when we look at industrial purchasing, that the manufacturer's purchasing department buys raw materials for production purposes from companies in the agricultural and extractive industries, as well as from other manufacturers.[9]

[9] A classification of goods for procurement purposes cannot be the same as a classification of goods for marketing purposes, for this reason. There are additional reasons, of course. A classification of purchased materials, for example, should be tied into our accounting procedure. It should be in consonance with our divisions of executive responsibility within the organization, for reasons that will be apparent later. See Stuart F. Heinritz, *Purchasing*, Prentice-Hall, Inc., 1951, pp. 200-201, for an example of an inventory classification.

Channels of Distribution

The term "channel of distribution" means the path or paths along which goods flow from producer to the customer. Its significant characteristic is the transfer of title to goods as they move through channels, rather than the physical flow of goods. The manufacturer may use whatever channels are most economical and effective for the distribution of his products. The channels for the distribution of consumer goods are those for (a) direct sale to the ultimate consumer, (b) direct sale to the retailer, (c) direct sale to the wholesaler, and (d) sale to or through an agent who sells to larger retailers or wholesalers. Industrial goods may be distributed by (a) direct sale to the industrial customer, (b) direct sale to wholesalers for resale to industrial users, and (c) sale to industrial users through manufacturers' agents or similar middlemen. Manufacturing companies tend to buy directly from the original sources of supply, rather than go through middlemen. The larger the concern, the more this tends to be true. The reasons will be discussed when we come to industrial purchasing. It is evident that the primary service objectives of the company are a basic determinant of the channel or channels of distribution that are most effective.

Sales Policy

A business policy has been defined previously as basically a statement of principle or principles, with their consequent rules of action, that condition and govern the achievement of certain business objectives toward which they are directed. The statement may be express or implied. A policy guides the thought and action of an organization, and its members, in the accomplishment of business objectives. Business functions are related to objectives through policy. It is evident that a policy is not a plan or a procedure. The latter are derived from objectives, policies, and functions, and their requirements.

A sales policy is one that governs the achievement of sales objectives. It guides the work of sales executives in planning, organizing, and controlling the work of the sales organization. Sound policies make possible an effective, economical performance of marketing functions. The problem of policy formulation has to do basically with the determination of what is sound principle underlying the solution of a general recurrent set of marketing problems. The question might be, for example, What are the principles governing a decision to market certain of the company's products to the retailer through company-operated warehouses

and our field sales organization, or to market them through wholesalers? There will be many problems to be solved with either decision. The use of premiums to attract potential buyers of some types of goods tends to increase as we approach the peak of a cycle or enter a period of increasing competition.[10] Should we give away premiums in an effort to stimulate sales? Why? The last question is the one that should force a careful consideration of the proposal, in the light of sound fundamental principles, before a final decision is made. It is doubtful that the idea will be very helpful if we are selling million-dollar automatic machines. The determination of the rules for the application of the principles follows after their selection. A successful dealer, handling the products of a farm implement manufacturer, has offered the following rules for increasing profit margins in the face of increasing competition. Most of them are old rules for a new situation.[11]

"Make profits rather than volume your goal; encourage employes with incentive payments; know your costs and use this information to make every segment of your business pay its way; turn on all the sales steam you can generate; try for a high proportion of repeat business; build a strong parts and service business, and keep close rein on charge accounts.

It is obvious that there must be some sound principles in back of these rules, since they have produced results. Since many of the rules are old, it is also obvious that something more is involved: the leader who directs its formulation and application. It is the dealer who is running the implement sales business in this case. The other phases of policy making, that were noted in Chapter 2, are quite as important in the marketing field as they are in any other.

Policies have been classified as (a) internal and (b) external, in so far as problems in business relations are concerned. Internal sales policies are those that govern the activities of the sales division and its members. The executive leadership of the sales division and the company have the initial right of decision concerning what principles and rules shall govern. The decision is subject, indirectly, to the veto power of the customer in the market place, of course. External policies are those that govern the company's relations with groups which are not a part of the company's organization. External sales policies are of two different kinds in a manufacturing organization: (a) those that govern relations with groups that

[10] Mr. Gorden C. Bowen, President, The Premium Advertising Association of America, has stated that sales of premium merchandise rose from between $500 million and $700 million in 1949 to $1.3 billion in 1953. Reported in the *Wall Street Journal* of April 20, 1954.

[11] Reported in the *Wall Street Journal* of April 6, 1954.

participate in or are affected by the company's performance of its marketing functions, and (b) those that govern relations with governmental agencies. The first category of policies includes those that have to do with customer relations, dealer relations, competitor relations, and similar problems. These policies are based on ethical principles, or should be, like any policy governing any business relations. The company's sales and general executives can legislate in these matters, provided that company policy is not contrary to general public policy. The second category of external policies includes those that must be based on and in conformity with specific public policy, as set forth in state and national legislation, and in consequent administrative directives. An example is the Robinson-Patman Act which governs pricing policy with respect to quantity discounts. Any company sales policy that tends to restrict competition, or results in unfair trade practices otherwise, will probably result in a rapid deterioration of the company's relations with the Federal Trade Commission, and possibly with the Department of Justice.

Executive Leadership and the Functions of the Sales Division

The actual work of the sales division includes those marketing functions that are assigned to it by the company's top administrative executives. These functions may not coincide with those that some marketing experts feel should be assigned, but in general they do.[12] The work of any organization, including the sales division, can be separated horizontally into two basic categories, managerial and operative functions. These categories break down into various levels or grades of managerial and operative service. Sales management functions are those of executive leadership within the sales division.[13] Sales operative functions are those that involve

[12] A National Industrial Conference Board report lists the following "administrative and supervisory responsibilities of sales executives": Administration of sales division, execution of sales policy, policy interpretation, coördination of sales activities, exports, advertising and sales promotion, promotion, publicity and public relations, sales costs control, credit and collections, expense controls, market analysis, setting sales quotas, trade and industry activities, dealer relations, handling important accounts, sales correspondence, customer service, supervising district and branch managers, making calls with field force, directing warehouse activities, selecting and assigning personnel, improving sales performance, administering sales training programs, allocating sales territories, bulletins, instructions, etc." *Sales Organization and Compensation of Sales Executives, Studies in Business Policy, No.* 28, N.I.C.B., 1948, p. 13.

[13] Some marketing authorities regard sales management merely as the management of the line function of personal selling. This view of it would not be acceptable to top management in some manufacturing companies. It conflicts with the concept that anyone who performs substantial leadership functions of planning, organizing, or controlling the work of others, whether in a line or staff capacity, is on the management team. H. H. Maynard and H. C. Nolen agree that "the sales management function includes what might be more accurately labeled marketing management." *Sales Management,* The Ronald Press Company, 1952, p. 4.

no substantial responsibilities for the direction and supervision of the work of others. This category includes the work of salesmen in our territories, as well as of clerks in our sales offices. A salesman may have a professional training. He is a professional operative in such case.

The work of the sales division also can be separated vertically into two basic categories, line and staff. The line functions of the sales division are those whose performance results directly and immediately in the accomplishment of primary divisional objectives. These objectives include the transfer of title to our products to satisfied customers in profitable quantities, at an economical cost of distribution. The line functions are obviously the selling functions. They can be broken down further into functions of personal and nonpersonal selling. Personal selling is the function of salesmanship. Nonpersonal selling is the function of advertising. An additional distinction can be made between advertising as a function of mass selling and salesmanship as a function of individual selling. Advertising, however, is used frequently in a manner that does not result directly in a transfer of title. It is used, rather, as a supporting function for personal selling. It operates in a staff capacity in such case. These functions will be discussed briefly after we have examined the structure of the sales division.

The staff functions of the sales division support its line functions. They are groups of activities that have evolved from the line functions of marketing, as a result usually of organization growth. They are set up, as in any organization, to provide for specialization and a division of managerial labor. The technical staff functions of marketing are marketing research including market analysis; sales forecasting; sales planning including the setting of sales quotas; product specialization; new product development; sales promotion; field warehousing operations; sales personnel management including the selection and training of salesmen; sales relations including public, customer, and dealer relations. Credit and collections are regarded here as a staff function of distribution, for reasons that will be discussed later. How much staff we have and how far it is developed depends on the size and rate of growth of the particular organization. The pushcart merchant, selling merchandise at the curb, has no staff. He performs a few simple staff functions personally, however. The "merchant prince" who heads a chain of department stores has plenty of staff. The growth of staff, from zero to thousands of staff personnel, was discussed in Chapter 4.

The coördinative staff functions of marketing have to do chiefly with control. These functions include such functions as the direction and co-

ordination of sales operations; the control of sales and other operating expense; coördination with the production and financial division in the execution of current sales programs. These include also liaison with top management staff, and the coördination of any other activities that have to do with the execution of the division's plans and programs. The numbers of staff personnel required for such staff control functions usually are relatively small. The contributions, nevertheless, are equally as important as those of our technical staff groups. The estimates and plans of the latter groups are of little value until they are executed effectively, economically, and on time.

The Structure of the Sales Organization

The structure of the sales line organization develops by direct devolution from ownership to primary operative performance of selling functions. The general position of the sales division in the manufacturing organization was shown in Fig. 6.1. An example of sales organization structure is shown in Fig. 7.1. It should be recalled that an organization structure is merely some relationship between certain groups of similar functions, and the responsibilities and authorities required for their proper performance. It is obviously some organizational relationship that will contribute economically and effectively to the accomplishment of the organization's mission, in the opinion of whoever designed it. The objective of structural design is a functional relationship that will facilitate the exercise of leadership and promote coöperation. It should establish accountability for group results. A good organization structure should lead to the acquisition of other organizational values that have been noted previously. Different organizational objectives require different organizational relationships. That is why Fig. 7.1 has been entitled "A Sales Organization."

The devolution of a line organization, by direct functional growth and differentiation downward, results in a division of primary operative labor and operative specialization. This division and specialization can be accomplished be only by grouping similar operative functions on some logical basis. The decision as to what is a sound basis is determined largely by certain basic factors in primary operative performance. Figure 11 shows that the principal bases for grouping line functions are: (a) product or service, (b) physical dispersion of operative activities, (c) the characteristics and requirements of the process or method employed, or (d) some dominant physical performance factor.[14] The first three are the more

[14] The National Industrial Conference Board Study of "Sales Organization and Compensation of Sales Executives" recognizes the following bases on p. 7: (1) *Functional*—Each major staff function serves all product lines; (2) *Product Specialization*—Each

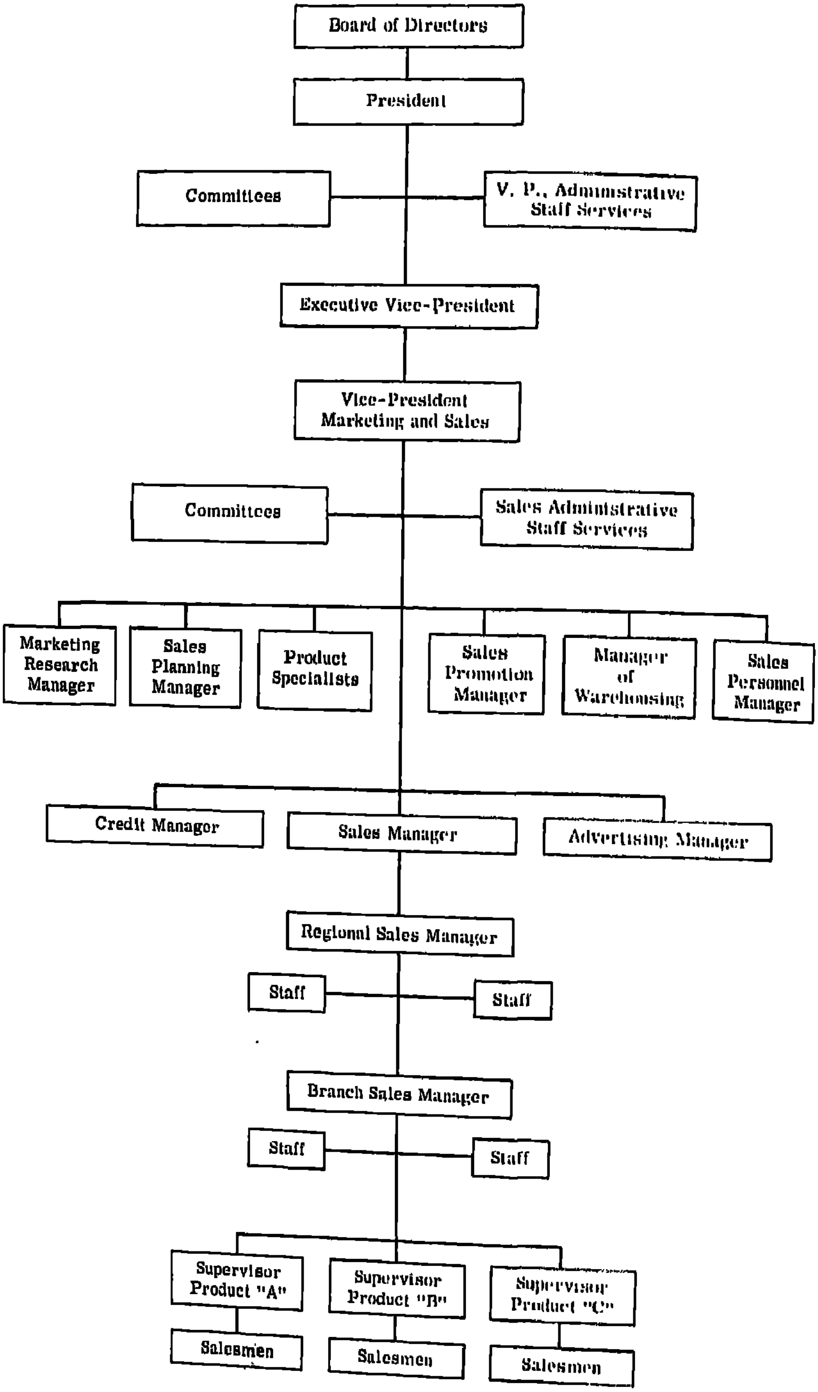


Fig. 7.1. A Sales Organization

important in the development of the sales line organization. The company in Fig. 7.1 has developed operative line specialization, under the branch sales manager, on a product basis. This is a practical basis for grouping functions when there are substantial differences, in the customer service objectives between product lines. The quality characteristics of the product and the conditions for its effective use will differ in consequence. This form of specialization enables the salesman and his supervisor to do a better job of analyzing customer product needs of a particular kind. The salesman can work with the customer more effectively, to get the maximum value from the product. The headquarters product specialists are staff personnel who are experts on product sales problems. These specialists should be competent to assist the line organization, at every level, in the solution of such problems. They perform other duties that will be noted subsequently. The second major basis, the physical dispersion of operative activities, is a geographical basis in the case of the sales organization. We develop an analogous problem in the production division of a manufacturing organization, with business growth and decentralization. A geographical grouping of line sales functions also has developed in Fig. 7.1. The work of personal selling, in this organization, is broken down into regions. Each region is broken down into branches. There is no evidence, in Fig. 7.1, of any use of the third basis, for functional grouping; the characteristics and requirements of the process or method employed.

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product has its own line-and-staff sales organization; (3) *Product Operating*—Each major staff function serves all product lines but each product has its own line organization; (4) *Product Staff*—A form of "functional" organization, in which staff includes a group or groups of product specialists who aid salesmen in the sale of particular products, or the customer in their use; (5) *Market Specialization*—The major staff functions are centralized, as in the "functional" type, but the line functions of personal selling are differentiated on the basis of a market classification; (6) *Geographical*—Line and staff functions of selling are differentiated and decentralized on the basis of geographical regions. (Note: Any structural relationship is "functional." Basis (1) is merely a conventional line-and-staff relationship. Bases (1) and (4) are primarily forms of staff organization. Bases (2), (3), (5), and (6) are primarily forms of line organization. There are some excellent charts, showing the use of these bases, on pp. 7-11 of the reference report. The above definitions are this writer's, but they are based on notations under the charts, as far as possible.)

H. H. Maynard and H. C. Nolen use the following "Bases of Division of Line Authority: (1) *Geographical Division;* (2) *Product Basis;*—". . . each product or group of products has its own marketing division with a considerable degree of autonomy, and coördination is secured in the higher managerial levels of the sales organization."; (3) *Customer Basis*—". . . that of organizing the department by customers, the units of the organization being grouped according to classes of purchasers served." (This is similar to the "market specialization" basis of N.I.C.B.); (4) *Channel of Distribution*—Organization on the basis of the channels through which goods flow to the customer. There would be, on this basis, divisions for direct sales to customers, sales to wholesalers, sales to chains, sales to retailers, etc. See *Sales Management,* The Ronald Press Company, 1950, pp. 53-55.

This basis may take the form of a division and grouping of such functions on the basis of the characteristics and requirements of customers or channels of distribution. The last basis, some dominant physical performance factor or factors, is not usually the principal basis for grouping line functions in the sales division. The use of branch warehouses, however, will certainly affect the organization of the branch sales manager's work.

It has been noted previously that advertising may be either a line or staff function. The work of advertising can also be broken down into its principal line and staff phases, or subfunctions. These phases also should be grouped on some logical basis. This is not usually an important problem in industrial concerns. The advertising manager may have a very large budget but a very small organization. He works usually through an advertising agency. The number of people under his command certainly is not the most significant factor in his salary.

Staff can evolve from line at any level where the particular staff service is needed. This has been indicated, in Fig. 7.1, in the organization under the sales manager. It is desirable to have the smallest number of service levels and staff groups that are compatible with competitive economy and effectiveness. Staff represents overhead expense.

The Line Organization of the Sales Division

The line organization for personal selling, in Fig. 7.1 extends from the vice-president in charge of sales, through the sales manager, the regional sales managers, the branch sales managers, the product supervisors to the salesmen. The vice-president, in a larger company, could have a general sales manager, regional sales managers, zone sales managers, district sales managers, territorial supervisors, or dealers. The characteristics of the line organization under the sales manager are determined by considerations of products, markets, policies, and methods, as well as sales volume.

The vice-president in charge of marketing and sales ranks as a line administrative executive. He must plan, organize, and control the work of his division, with the assistance of his line and staff subordinates. His work is subject to general administrative direction by higher line authority; in Fig. 7.1, the executive vice-president. The marketing vice-president must coöperate with the general executives in charge of other major divisions in determining sales, production, and financial objectives. He is usually a member of the company's executive committee for this reason. The line and staff functions for which the vice-president is responsible have been noted previously. Superior leadership and executive ability are basic requirements for his job, since the vice-president is a top line executive.

He must have some practical experience and a thorough knowledge of markets and selling. It is imperative that this vice-president be a man of vision and enthusiasm. The leadership on lower levels of an organization tends to reflect the point of view and attitude of its chief executive. The inspiration, encouragement, and coöperation that the field organization receives from the home office is a reflection of the ability and attitude of the marketing and sales vice-president. He is therefore a fundamental factor in the morale of the selling organization. There may be a place in the world for a chronic pessimist, but not in a leadership position in the sales organization.

What has been said about the vice-president is true necessarily for his subordinate line executives. Their duties are assigned by him, and they operate on the basis of delegated responsibilities and authorities. The headquarters staff must serve them, as well as the vice-president. This staff has no line authority over them. The subordinate line executives, under the sales manager represent various grades of operative sales management. Top management is concerned more with problems of long-range planning and major problems of organizing. It is concerned to a lesser degree, in point of time spent, with administrative control. Bottom management is concerned more with operative control. It is concerned to a lesser degree with short-range planning and minor problems of organizing. A supervisor under the branch sales manager, for example, spends most of his time on the direction and supervision of his salesmen.

Credit and Collections

The credit function is the work of determining the conditions under which the customer should be permitted to buy goods on trust. It involves a decision concerning the amount of credit to which the customer is entitled. This decision rests on a determination of the customer's ability and intention to pay. It is based usually on credit information concerning the customer. The collection function is concerned largely with obtaining payment for past-due accounts. It obviously involves important relations with the customer. The general nature of these functions, and their position in the organization, were discussed in Chapter 6.

Some marketing experts believe that the credit department should be regarded as a "line" organization. The proponents of this viewpoint note that a large proportion of the sales of many concerns is done on credit.[15]

[15] Total installment credit reached $28 billion, approximately, in 1955. Automobile installment credit accounted for approximately $14 billion. Installment sales represented approximately 70% of all automobile sales during that year.

They contend that the credit manager has, or should have, the final right of decision concerning the extension of credit to customers, subject only to general administrative approval. These decisions may affect directly the ability of the customer to consume the company's products. Credit is a line function, in the opinion of these experts, because it enters directly and immediately into the process of distributing customer goods and services. The provision of cash and credit, for use by the organization and its components, is obviously a line function of finance. The credit manager's function is concerned primarily with the granting of credit to the customer. It facilitates the consummation of a sale. The collections function renders chiefly a facilitative service. The credit department is regarded here as a staff organization, for these reasons. It has been placed under the vice-president in charge of sales and marketing, in Fig. 6.1. The credit manager is on the same organizational level as the sales manager. He has the right of decision concerning credit applications, acting for the vice-president. The sales manager can take a disputed credit application to the marketing vice-president, of course. It would not be advisable, unless the sales manager were able to demonstrate, beyond reasonable doubt, the soundness of his position. The vice-president would normally support his credit expert, in case of doubt.

This is a specialized professional field. The growth of the credit function has required the development of extensive machinery for supplying credit information. Complex credit techniques have been designed. A proper performance of the credit and collections functions requires the application of a professional knowledge of credit policies and practices by a trained credit executive. The discussion of specific policies and practices must be left to texts on the subject of credits and collections.

Advertising

Advertising has been defined above as a function of nonpersonal mass selling. This function can result directly and immediately in the transfer of title to goods by the seller to the buyer. Advertising is a line function of sales in such cases. It is a staff function when it is chiefly a supporting function for sales. Advertising is concerned chiefly with the factor of possession in the distribution of goods. It can direct the attention of potential customers to goods and services that will satisfy their needs. It can educate these customers concerning the possible uses of our products. Advertising can create new demand for old products, or a demand for new products, through its educational action. It may produce an increase in sales volume that will reduce manufacturing costs. Profits should in-

crease at a faster rate than volume, as sales go above our break-even point. Advertising may make other contributions to the economy and effectiveness with which the company accomplishes its objectives.

Personal selling can accomplish the same results. Advertising can accomplish these results for some products more economically and effectively. This may be true when the company is manufacturing consumer goods, rather than industrial goods. The advertising function is usually important in any manufacturing concern, but the relative importance of personal and nonpersonal selling will vary between concerns, as indicated. The two functions are complementary rather than competitive with one another.

The work of the advertising department depends on what duties are assigned, like any other organization. The department's functions usually include the following, once general marketing objectives and policies have been determined: (1) analysis of customer needs and desires (this may be done for advertising by marketing research); (2) determination of the requirements for a successful presentation of the product; (3) planning the advertising campaign, including budgetary planning; (4) writing the advertising copy; (5) making the advertising layout; (6) pretesting the advertising to determine its pulling power; (7) selecting the most effective advertising media; (8) determining the best means of reproducing the advertisement; (9) evaluating the results of the advertising campaign for current corrective action and future planning. Some advertising experts feel that such functions as market analysis and sales promotion should be assigned to the advertising department. They have been set up in an independent staff position, in Fig. 7.1, for reasons that will be apparent shortly.

Many of the above functions may be performed for the advertising department, in whole or in part, by an advertising agency. The advertising manager is the company's liaison officer with this agency. He is still responsible for the contributions to the company's success that may reasonably be expected from a proper performance of the advertising function. The advertising manager is responsible for the administration of an advertising appropriation that may run into millions of dollars. He is subject, of course, to general policy and to general administrative direction and supervision by higher line authority.

Marketing Research

Marketing research is a major technical staff function of distribution. Such research may be defined as the function of collecting, classifying and

analyzing marketing facts, the development of logical conclusions from these facts by valid processes of inductive reasoning, and the interpretation of the significances of these facts and conclusions in the marketing process under a given set of circumstances.[16] The objectives of marketing research are obviously facts, conclusions, and interpretations that will clarify the nature of the company's service objectives and indicate the requirements for an effective economical achievement of them. These facts and conclusions are necessary for the formulation of sales policies and plans. Some of them are necessary also for purposes of general administrative management. Most manufacturing companies, above the small business size, have some sort of a marketing research group.[17] The development of the function may vary greatly between companies. The widespread development of marketing research indicates its great importance.

The location of a major staff function in an organization is important. The operation of the function may be too expensive if it is located on too high a level. Its operation may be ineffective because it is out of touch with the activities that it should serve directly. The particular staff function may be ineffective if it is on too low a level, because it lacks the scope, prestige, and opportunity to do the job that is expected of it. The

[16] The American Management Association says that "marketing research is critical study and evaluation on a continuing basis of present and potential markets and of marketing operations to the end that policies, methods, and performance in this area may be governed by supportable conclusions and may stand the test of objective appraisal or measurement." *AMA Research Report No. 5*, "A Company Guide to Marketing Research," 1944, p. 7.

R. T. Browne and C. F. Phillips regard marketing research as a function of providing and analyzing marketing facts so that they can be used as a basis for policy decisions in the field of marketing. *Marketing by Manufacturers*, Richard D. Irwin, Inc., 1950, p. 72.

D. M. Hobart cites the American Marketing Association's definition; "the gathering, recording and analyzing of all facts about problems relating to the transfer and sale of goods and services from producer to consumer." *Marketing Research Practice*, The Ronald Press Company, 1949, p. 3. (This definition has influenced the thinking of many competent students of marketing research. It is too narrow in the opinion of this writer, nevertheless.)

[17] D. M. Hobart also cites an NAM-AMA study of 1947 which showed that "almost half the companies with annual net sales over $5,000,000 have marketing research departments." *Op. cit.*, p. 17. (How big a company is one doing a $5,000,000 business? It is one that probably employs between 350 and 700 employes, under present conditions. This depends, of course on the percentage of direct labor in the sales dollar and the average annual wages of operative employees in manufacturing concerns. Some of our big manufacturing companies sell billions of dollars of products.) A later AMA study showed that 74% of all concerns covered by the survey, and 87% of the large concerns, had full-time market research specialists or departments. *Company Practices in Marketing Research*, Research Report 22, Amer. Mgt. Assoc., 1953, p. 20. The rapid growth of the function is indicated by the increase in the percentage of concerns with full-time market research services.

director or manager of marketing research reports to the vice-president in charge of marketing and sales, in Fig. 7.1. This director reports, in some concerns, directly to the executive vice-president or the president. Some tendency has developed in recent years to make marketing research in manufacturing organizations a department under the executive in charge of top administrative staff services. This executive is the vice-president for administrative staff services in Fig. 6.1. The direction of movement has been, apparently, toward the level of top administrative management. The reason is probably obvious. The work of getting a factual fix on the primary service objectives of a business organization is a matter of primary interest to every major division of that organization. The marketing research department should coördinate its work and thinking with engineering research and design, for example, in the case of new product development. The rule is that the coördination of intergroup activities should take place on the level immediately above the particular groups involved, whenever practicable. Those marketing research functions that are concerned chiefly with marketing processes and practices can and probably should be left in the sales division, under its vice-president.

The marketing research function breaks down into certain phases or subfunctions. It is important to identify them, because they are the basis for organizing the function. A technical planning function breaks down into groupings of the mental work required. This work depends, obviously, on the principal kinds of problems that are normally assigned to the particular technical staff department for solution. A product engineering department, for example, is organized usually on the basis of the work of designing the principal types of products and their components. A business research organization breaks down, similarly, into the work of collecting or developing, by research methods, the information required for a solution of these problems. This information has to do with facts, principles, and conclusions concerning the factors and functions in the problems. These factors and functions are determined by the objectives involved. The principal phases of marketing research therefore depend on the nature of the marketing problems about which it must furnish information. The extent to which these subfunctions are differentiated and developed will depend on the size of the company and the point of view of its management.

The definition of marketing research is broad enough to include any investigation and analysis of marketing problems that requires the use of research techniques. There seems to be substantial agreement among students of marketing research that the following functions may be assigned

to it: (a) general economic research, (b) market research, (c) research into marketing methods, (d) product research, and (e) the determination of sales performance standards. *General economic research* and analysis includes the study of such problems as seasonal, cyclical, and secular trends of the company's business; the effect on demand of population shifts and trends; business forecasting; evaluation of general competitive conditions; pricing problems; and similar problems. *Market research* deals specifically with the market itself. It includes the study of market location, customer preferences and buying habits, market potentials, and channels of distribution. *Product research* deals with the marketing aspects of the product as a vehicle for carrying customer satisfactions. Such research does not include the technical phases of new product development and design. It includes the study of such problems as nontechnical product evaluation, determination of the competitive position of each product, evaluation of competitor marketing policies and methods for particular products, the simplification of product lines, the modification of old products for new uses, and similar problems. *Research into marketing methods* includes the investigation and analysis of primary marketing methods. These are the methods used in performing the line functions of personal selling and advertising. This research does not include the study of marketing management methods, if we have a sales administrative staff services group, as shown in Fig. 7.1. *The determination of sales performance standards* includes the development of measures of marketing economy and effectiveness, when this work involves the use of marketing research techniques. Much of the information required for the determination of such standards is produced previously by economic, market, product, and methods research. One technique, time-and-duty study, was noted in Chapter 3 when discussing functional analysis. This technique has been used in the marketing field to determine reasonable time standards for the principal phases of a salesman's work, and of course to improve his methods.

There are instances in which certain phases of sales planning, sales promotion, analysis of distribution costs, and other marketing staff functions are assigned to marketing research. Some of the duties assigned to it by some authorities fall properly in the fields of sales planning or control.

Marketing research has its limitations, like every other function. Quite a span of time may elapse between the initiation of a marketing study and its completion. Some of the findings may be invalidated by a rapidly changing situation. There are the usual limitations of statistical techniques. The marketing research director may not get the support, the

coöperation, and the budget that he requires. He may not have the necessary training or ability, on the other hand. No function can be more effective than the individual who performs it. The great contributions of marketing research have more than overcome these and other limitations. They have won for it a permanent place in American manufacturing organization.

Any discussion of marketing research techniques are beyond the limits of this book. There are various statistical and field techniques for determining market potentials for areas and products. There are various methods for product testing. Technical product testing enables a manufacturer to "compare the physical characteristics of his products with those of his competitor and come to some conclusion as to their comparative merits." This is an engineering problem usually. Consumer product testing "comprehends those activities whereby the consumer tests the product through actual use."[18] There are questionnaire methods for determining customer preferences. A very important problem, under competitive conditions, is the prediction of the effect of the introduction of a new product. H. D. Wolfe has pointed out that this breaks down into two general phases; statistical analysis of the effect of new product sales growth on older competing products, and marketing research in test towns. The latter are selected communities in which conditions are representative of the particular marketing problem. Test-town studies involve an evaluation of such factors as the total market for the class or type of product, the competitive positions of the principal products of this type and those of secondary importance. These studies consider the probable competitive effectiveness of the new product, the percentage of the total business that probably will go to the new product, the relation of this competitive position to an index of community purchasing power. They may include a short-run forecast of probable sales by territories, and a long-range forecast when enough data is available to permit the fitting of an exponential or growth equation.[19] Any good book on marketing research will present many other techniques.

Sales Forecasting

Business forecasting has to do with the prediction of business phenomena during some future time periods. Such forecasting may be con-

[18] D. M. Phelps, *Planning the Product*, Richard D. Irwin, Inc., 1947, p. 77.

[19] Harry D. Wolfe, "Accurate Forecasting—Simple Tools Make It Easy," in *Management Faces New Problems*, Society for Advancement of Management, 1954, pp. 116-123.

H. H. Maynard and H. C. Nolen give a good brief discussion of the test town technique in *Sales Management*, The Ronald Press Company, 1952, pp. 156-157.

cerned with general economic, industry, and company business conditions. Sales forecasting is concerned with the prediction of the physical and dollar volume of sales for a coming time period. It is done usually by product classes, price lines, and territories.

Sales forecasting enables us to anticipate the requirements for a satisfactory accomplishment of our primary service objectives. It enables us to specify these objectives concretely, in terms of quantity, quality, expense, and time, for definite time periods. The objective is the starting point of our planning. An intelligent exercise of initiative depends on a reasonably accurate preview of the objective. The principle of the initiative says that "the ability to plan, organize, and control an action depends on the ability to acquire and maintain the initiative."[20] Seizure of the initiative by one's opposition reduces planning to the level of expediency, and lowers the effectiveness of planning accordingly. This can be fatal in a highly competitive system of private enterprise. Sales forecasting underlies sales and production programming. Financial plans, procurement plans, process plans, employment plans, and other important plans depend on these programs.

Sales forecasting is associated closely with marketing research. It is regarded by many as a part of such research. Economic forecasting has been differentiated from sales forecasting in some large corporations. Economic forecasting is a part of the top administrative staff group in such case. There has also been a tendency for marketing research to move into this top staff group, as noted above, because of an interdivisional interest in the determination of company objectives.

Any detailed discussion of forecasting techniques also is beyond the scope of this book. It is possible only to point out that there are many techniques, and to note some of the more important. Forecasting methods may be classified according to the time span over which they are most effective. We have short-range, intermediate, and long-range forecasts. Short-range forecasts are those covering a period of one year or less. This is the time span of the cycle of seasonal variation. Intermediate forecasts usually cover a period of 1 to 5 years. This covers the span of most business cycles. Long-range forecasts cover a period of 5 years or longer. Some forecasting techniques are more effective for certain ranges than for others.

Forecasting methods can be classified also on the basis of their distinguishing characteristics. We can distinguish, on this basis, between: (a)

[20] R. C. Davis, *The Fundamentals of Top Management*, Harper & Brothers, 1951, p. 78.

the method of coördinated opinion, (b) statistical forecasting techniques, and (c) methods based directly on market research. The method of coördinated opinion relies on the observations and practical experience of salesmen and/or dealers. They are directly in contact with the customer. Figure 7.1 can be used to illustrate the general method. Personnel in the regions and branches, down to and including salesmen, are given some training in getting and evaluating customer opinions concerning the near-term business prospects. Each salesman submits his estimate of his probable sales for the coming month and quarter, by product classes and price lines. Each product supervisor evaluates, modifies, and consolidates the individual estimates to get a product sales forecast for the branch. The branch estimates are consolidated to get a regional forecast; the regional estimates to get a company forecast. The forecasts at each level may be modified also by committee review and recommendation. The dealer and branch sales organizations may be used to collect local business data, in addition. The coördinated opinion of the line organization may be matched against an independent statistical forecast in the home office. This method has the greatest value for short-range forecasts.

Statistical forecasting methods apply mathematical treatment to business data, based on the theory of probability, to get a prediction of business volume and conditions at some future time. The definition makes it sound difficult and expensive. Many methods are simple and inexpensive, as a matter of fact. One method merely corrects company sales for seasonal variation and secular trend.[21] The resulting curve of cyclical sales is then extended to get a short-range forecast. Seasonal and secular sales for the forecast months are added back in to get a total forecast. Another short-range method gets the median ratio of a given quarters sales to annual sales over a number of years. This ratio is applied to current quarterly sales to get a forecast for the coming three quarters. This method makes some crude accounting for seasonal influences. Another short-range method is based on the company's competitive position. This position is indicated by the usual percentage of company sales to total sales of the industry. This percentage is applied to forecast industry sales. The usual

[21] Seasonal variation is merely the tendency of business or other data to vary from month to month, with the cycle of the seasons, in accordance with some definite pattern. The effects of this tendency can be removed from the data by the application of "seasonal coefficients." Secular trend is the long-term trend of growth or decline of a time series of data. Statisticians can represent it by a straight line, a moving average, an exponential series, or some other fitted curve. The business cycle is intermediate, in point of time, between the seasonal and secular trends. The substraction of the latter trends from a time series of business data leaves only cyclical and minor variations.

percentage of each product line's sales can be applied to forecasted total company sales.

A method that is helpful in connection with intermediate forecasting determines the normal range of variance of current cyclical sales from the secular trend of sales. This range is determined by the statistical technique of standard deviation. It is obvious that the probability of a continuing trend, either up or down, diminishes as sales pass out of a normal range. A more complicated method employs what the statistician calls a "regression equation." There may be various business activities whose ups and downs normally precede the variations in our sales. These activities are barometers of our business, in such case. They can be used to forecast our sales. The number of months by which variations in these activities lead corresponding variations in our sales can be determined by the process of *statistical correlation*. The *cofficients of correlation* are used in setting up a forecasting equation. This "multiple regression equation" integrates the predictions of a number of barometers into a single forecast.

Long-range forecasts are based on the secular trend of the business. These forecasts must also take into account such intangibles as technological progress, population trends, changes in social customs, political and economic changes in the direction of socialism, and others. This, and any other forecasting, requires judgment. Statistical forecasting offers no mathematical substitute for executive judgment. It can furnish an excellent basis for it, however.

Market research also may use statistical techniques. It is basically a fact-finding, rather than fact-treating approach, however. Marketing research can nevertheless result directly in a sales forecast. It can determine the market potential for a marketing area. This is merely the total volume of sales of a particular kind, type, or class of product that can be expected. It can also determine the percentage of this total volume that the company can reasonably expect to get. The application of this percentage to the expected total potential of a given area during a coming period gives us an estimate of sales potential. It is obviously a forecast. This approach may be particularly helpful when we are invading new territories, or introducing new products into old territories. No adequate statistical data concerning the sales of our product may be available, in such case.

The use of forecasting techniques, when applied properly to adequate, appropriate, and reliable data, can produce estimates of sales volume by product classes, price lines, and territories. The consolidation of these estimates into a company forecast supplies the basis for sales, production

and financial programs. Any single forecast may be unreliable, of course, because of forecasting errors. Many concerns follow the practice of overlapping forecasts for this reason. In making quarterly and annual forecasts, for example, the current month is dropped and a month at the end of the new forecast period is added. Repeated estimates for the same month, as we move through time, tend to correct initial errors.

Sales Planning

Sales planning is the work of determining bases of effective action for the sales division. It is fundamentally the same as any planning anywhere, except that it deals specifically with the work of the division. Such planning has to do, in other words, with the determination of how much business, in terms of dollar and physical sale volume, can be done with which products in what territories, during a coming time period. It is concerned with what action is required to accomplish the mission, and how it should be conducted. Sales planning determines what resources in terms of personnel, money, facilities, and time must be supplied, and similar questions. It is concerned with time objectives, such as the date of first showing of new models, the closing date of a forecast period, or something of this kind. Sales planning does not include scheduling, which is a function of control. A result of such planning probably will be a divisional recommendation of a sales program. This program becomes the basis for the development of production and financial programs, when modified by conference under top management direction. Sales planning is based on the results of marketing research and sales forecasting, as well as sales facts and records, plus executive experience and judgment.

Sales planning includes usually the determination of sales quotas. These are merely operative objectives for our regions, branches, territories, and salesmen. Such quotas are broken down by product classes and price lines and become the starting points for operative planning and control of sales activities on lower echelons.

The term "merchandising" usually includes sales planning and more. The term may include product planning and development, the determination of both sales and production programs, inventory planning and control, and other functions that involve interdivisional relations in production and distribution. It is evident that what the proponents of this function have in mind is a top management staff function of technical coördination. Sometimes they do not know enough about management to realize it. The function of inventory planning and control in one company is in the process of moving from a top management staff location back to

a location in the manufacturing division, from which it came some years ago. This inventory function, in its present position, appears to have subtracted from the economy and effectiveness of the company's competitive efforts, rather than to have added thereto. What might have been a constructive development has died on the vine, largely because the executives concerned have not understood the distinction between administrative management and operative management. The general administrative phases of management functions, both line and staff, should be performed at the top management levels of the organization. The major administrative and operative phases should be decentralized to the major divisions. The general administrative phases of marketing research, for example, should be performed by top management staff. The remaining phases should be performed by the sales division. The general administrative phases of new product development, for example, should be performed by top management staff. The remaining phases should be performed by the sales division or the manufacturing division, depending on the work, as we shall see shortly. A sales coördination meeting of top marketing, manufacturing, and financial executives is shown in Fig. 7.2 (see p. 212).

Product Specialists

The product specialists in Fig. 7.1 are staff experts in the selling of particular products. There may be a specialist, known as a "product manager," for each major class of product, if the company is big enough to afford such specialization. Each product mänager may have a small headquarters group to assist him in his work. This work has to do with advising and assisting the line organization on lower echelons in solving difficult selling problems for particular products. The product managers have no line authority, even though the sales organization may be organized on a product basis at the operative level, as in Fig. 7.1. This is merely another example of staff parallelism, a problem that has been discussed in Chapter 6. These specialists should and do participate in sales planning and product development.

New Product Development

The product may be any physical thing that is created for sale by some manufacturing process. It is a vehicle that carries to the customer certain utilities. These utilities give to the product its need-satisfying capabilities. The quality of the product is that combination of characteristic attributes that give to the product its utilities. These quality attributes distinguish one product from another. We shall see the nature of them when we look

at the problem of quality control. It is sufficient to note here that they give to the product any unique properties that it may have.

Product planning is the function of determining the attributes that the product should have to accomplish its mission. Product objectives include quantity and cost, as well as quality. Product planning is based on product research in our larger companies. The alternative may be too much trial and error, at the customer's expense, for competitive effectiveness. Product planning has two principal phases; the economic and the technical. The economic phase of product planning has to do with such questions as what sort of a product does the customer want and why, and what will he pay for it. The technical phase of product planning is concerned with such questions as what does a product have to do to satisfy these wants, how does it do it, and what sort of technical product requirements does this set up. There are many other questions, of course, that are associated with each phase. Product research develops the facts and principles that are necessary for satisfactory answers for these questions. This also has two phases, corresponding to the phases of product planning; customer research and industrial research. Customer research and other functions of marketing research have to do with the determination of customer needs and product satisfactions. Technical product research is a phase of industrial research. Product development, strictly speaking, has to do with creating and refining desirable attributes in the product, after a satisfactory initial product plan has been made. Some people use the term to mean about everything that has been discussed above.

Process planning also affects new product development. A product that can be sold only at a loss is something less than a business triumph. Manufacturing costs are usually an important factor in profits. Process planning determines how the required quality attributes can be built into the product, at a cost that we can afford to pay.

The objectives of product planning and development are values that affect all classes of business objectives. The primary objectives are usually increased sales volume and an improved competitive position in the industry. The company tries to accomplish these objectives by giving the customers better value at the same cost, the same value at a lower cost, or new values for new needs at a cost that is commensurate with the new service. The company may develop a full line of products, so that its customer can satisfy his needs without recourse to a competing line. Progressive obsolescence may be an objective. Such product obsolescene is rather an effect of competition and technological progress. The collateral objectives include a better profit margin, made possible by the

unique services of the new product. The volume of business that is generated by the new product may produce a higher rate of capital turnover. This in turn makes possible a higher rate of return on investment, of course. New product development is a foundation stone under business growth, capital gains, and increasing employment. It is a major factor in industry's discharge of a collateral social obligation; a continuous contribution to an increasing standard of living for our people. The secondary objectives of product development are those that are associated with cost reduction. These objectives include the utilization of excess capacity by products that will give us a balanced work load on our equipment. The company may develop off-season lines for the same reason, and in addition to stabilize employment. A line of by-products to reduce losses from waste and scrap may be developed. Phelps notes the possibility of reducing unit sales costs; a full line may permit the salesman to take larger orders at the same cost per call.[22] There are other cost savings from new product development.

The general method of approach to new product planning and development can be summarized as follows:

PRELIMINARY PRODUCT PLANNING

1. *Recognition of the Problem*
   a. New product proposals
   b. Initial screening of proposals
2. *Preliminary Investigation and Analysis of the Problem*
   a. Collection of facts concerning the proposal from secondary sources
   b. Coördination of authoritative opinion within the company
   c. Staff recommendation
3. *The Development of Tentative Solutions*
   a. Top management decisions
   b. General project specifications for the developmental projects
   c. Research and preliminary design
4. *The Remaining Steps of the Scientific Method*
   a. Have to do largely with product development and refinement prior to general sale and distribution.

New product proposals, or proposals for the modification of old ones, may be received from any source, in or out of the organization. These proposals should be presented in writing to a product committee for initial evaluation. This committee is composed of competent line and staff personnel from the sales and manufacturing divisions. Many of the proposals will probably be thrown out at this point as impracticable. Some top manage-

[22] D. M. Phelps, *Planning the Product*, Richard D. Irwin, Inc., 1947, p. 22.

ment staff group should collect additional facts concerning proposals that are passed, to throw further light on their feasibility. These facts should be obtained as quickly as possible from readily available sources. This information concerns such questions as the requirements that the product must meet to make a unique contribution to customer service. It has to do with competing products rendering a similar service. The data will include facts on the patent situation with respect to such products. Any governmental regulations that may affect product design and marketing should be reported. Any pertinent facts that the marketing research department may have in its files should be made available. This information should be boiled down and briefed for evaluation by interested technical staff groups within the organization. The marketing feasibility of the proposal should be evaluated by the sales division, and the technical evaluation by the manufacturing division. The opinions of the experts probably will be coördinated by the product committee. The result is a staff recommendation for top management, if the proposal still looks good. Otherwise it will be thrown out at this point. Top management consideration will bring up questions of general objectives and policies, and of course a little matter of money. The treasurer, or the comptroller, is frequently a member of the company's executive committee. The engine that drives a project may be personnel, but it is powered with cash. The project cannot become airborne without it. A budget appropriation for the developmental project will be granted, with conditions and restrictions probably, when we get the "green light" from top management. It will be necessary, then, to work up a general project specification, with the concurrence of those who must participate in its execution. This specification will modify or elaborate the original staff proposals, as required by top management. It will specify agreed project objectives, the general conditions of successful accomplishment, and any controlling general policies. The specification will state the general assignments of design and developmental work to the divisions. It will delegate the corresponding responsibility and the required authority. It will indicate the general phases of the project and the amount of time that can be allowed for each of them. The specification will give other project information. It will be seen that the administrative planning for the project is basically general and organizational. Operative planning and control for assigned phases of the development project are divisional responsbilities. These phases may include technical research, preliminary product design, experimental engineering, certain marketing research, preliminary process design, pilot line production, and experi-

mental marketing of the new or modified product. These problems will be discussed briefly, in connection with the general problem of product and process design. The end objective of the developmental project is a salable product that can be produced and distributed in quantity at a profit.

It is necessary and desirable to talk before acting. Results flow from action, however. The project should be activated by an administrative order of a top line executive, the executive vice-president or the president. The order is usually issued in writing in a large organization. This order can be originated for this line executive by a top administrative staff executive, under conditions noted previously.

Responsibility and accountability are individual rather than group problems. The individual executive may be in charge of a group, but he should be accountable personally for group results. It is unlikely that satisfactory results will be obtained otherwise. A clear distinction should be made between line and staff responsibility, however. Who should have staff responsibility for new product development? It is evident that he should be located on the level of top administrative management. He would probably report to the vice-president for general administrative staff services, in Fig. 7.1. His title? Some companies call him the manager for product development, new product manager, or by some other title that they think is descriptive of his function. His job is to stimulate and coördinate interdivisional thought and action in the field of product planning and development. He has no line authority over the divisional groups that are working in this field. A product committee has been mentioned previously. Its function is to integrate the ideas of the principal executives who are concerned with general product problems. The product manager would be a member of the committee, of course.

This may seem like a lot of work, before we even get into the details of product planning and development. It is not, when many millions of dollars may be riding on the decisions that we have been making. It is, in a small company that does not have the volume of business to afford the staff. The same general method will apply, however. The dimensional details of a pattern for a suit of clothes will vary with the size of the individual, but the same general pattern applies to all sizes of a particular model, nevertheless.

We have talked as though we always develop our own new products. We may also buy patents, or lease the right to produce products, on a royalty basis, from other concerns.

Sales Promotion

Sales promotion includes those selling activities that supplement both advertising and personal selling.[23] It is obviously a staff function. It has been shown in an independent position in Fig. 7.1. The duties of the sales promotion group vary between concerns. This group generally operates through the line selling organizations, rather than directly with the customer.[24] It supplies facilitative services for selling, such as various dealer aids, and makes similar staff contributions.

Warehousing

Warehousing problems arise when inventories of finished goods are held, pending sale, at divisional or branch locations. These inventories are usually charged to the sales division, resulting in a transfer of accountability from the manufacturing division. Warehousing of such inventories becomes a problem for sales management when this occurs. These problems are not different fundamentally from the warehousing and storing problems of the manufacturing division. They will be discussed later in connection with the work of procurement and supply for this reason.

Sales Personnel Management

The marketing and sales division may have a personnel manager. This division does not have one in many companies. The personnel strength of the division may be very much less than that of the manufacturing division. The personnel director, in Fig. 6.1, may handle the staff personnel services for all headquarters departments. The personnel problems of the divisional field organization must be handled, in such case, by its line executives. Sales personnel problems are important, nevertheless. The selection and training of salesmen, for example, is an important personnel problem, regardless of company size. There are others. The factors in these problems are peculiar to the work of the sales division. The fundamentals are not. These fundamentals will be discussed later in connection with the work of the personnel director.

[23] H. H. Maynard, and T. N. Beckman, *op. cit.*, p. 426.

[24] The Chas. Pfizer Co., pharmaceutical manufacturers, increased its total sales from $7 million in 1940 to $127 million in 1953, largely through sales promotion. It sponsored golf tournaments, fishing tournaments, and other activities for doctors. They involved direct contact with the customer, but no direct selling. The *Wall Street Journal*, June 6, 1954.

Fig. 7.2. A Sales Coördination Meeting of Marketing, Manufacturing, and Financial Executives. (Courtesy, Pontiac Division, General Motors Corp.)

The Sales Office Manager

Much the same thing can be said for the work of the sales office manager. The fundamentals of office management will be summarized briefly, under that heading, in a later chapter.

Sales Coördination and Control

The sales control group assists the line and other staff groups in coördinating the execution of plans and programs. The release of approved plans and programs to lower echelons should take place through this office. It is a routine operation. This group can serve as an office of issue and record. The control group should schedule the activities required for the execution of sales plans. This may include the scheduling of salesmen. The control group should receive reports from the regions and branches. It may receive reports directly from salesmen, in small organizations that

have no extensive field organization. The sales analysis function may be assigned to this group, since it is a comparison function of sales control. The group should also maintain close staff coördination between the sales and manufacturing divisions in the execution of sales and production programs. It may perform any assigned duties that have to do with the coördination of thought and action in the execution of plans, but not with the coördination of thought and action in planning.

PROBLEMS

1. A firm engaged in manufacture of plastic products produced several types of plastic display stands for use by a restaurant chain. The management of the chain informed the plastic manufacturer that it was looking for a way to reduce the expense of maintaining satisfactory finishes on its tables and counters. The plastics manufacturer, after some months of research, produced a plastic surfacing material for this purpose. It purchased the equipment required for quantity production of the item. However, it discovered after several months of operation, that the restaurant chain had purchased as much of the surfacing item as it needed. Furthermore, several other firms were beginning to market a similar product. These firms claimed for their product some superior features, such as imperviousness to cigaret burns. The plastics manufacturer eventually was forced to discontinue its manufacture of the line entirely. It disposed of the equipment at a considerable loss.
   (a) What sales forecasting and/or marketing research methods might have been helpful in this case? Why?
   (b) The company was unable, apparently, to meet the quality competition of other manufacturers of this plastics item. What are the principal functions whose poor performance may have caused such a major difficulty? What may have been the principal limiting factors in this problem?
2. A medium-sized toy manufacturing firm specialized in the manufacture of miniature models of name brand trucks, buses, earth-moving equipment, and similar items. The company was noted for producing a high-quality line. All toys were made of metal and were individually finished and painted. The quality of its product justified a relatively high price. Distributors reported some buying resistance, nevertheless. They expressed the feeling that a product which could be sold for a lower price would be a welcome addition to the line. The toy firm added an additional research man to its staff whose function it was to work toward meeting the needs expressed by distributors. After six months, it was felt that a new kind of toy could be produced with cheaper materials and on a mass production basis. The firm hesitated to take further action until it could determine the probable success of adopting different production policies.
   (a) Was the company wise in developing the new line of toys?
   (b) What principles and procedures should it follow in solving the problem?

CHAPTER 8 • Plant Location

Physical Factors in Manufacturing Operation

THE performance of functions in any organized business activity is usually conditioned in some degree by certain physical factors that are peculiar to it.[1] The purpose of such factors is to supplement and extend the abilities of the individuals and groups composing the organization, to the end that they may do their work more economically and effectively. In a manufacturing concern, these physical factors may include such items as materials, machines, buildings, tools, office equipment, etc. In most concerns, fixed and working capital are represented by such factors. It is the responsibility of ownership, through the agency of management, to implement the organization with the proper kind and amount of these physical factors.

What constitutes the proper kind and amount will differ with each manufacturing problem. The characteristics and requirements of manufacturing functions, both managerial and operative, are determined fundamentally by the company's service objectives. In part, they are expressed concretely in product and process specifications, with their related standards of quality. The characteristics of the required physical factors are determined primarily by the requirements of specific functions for proper performance. These factors may modify secondarily the characteristics of the individuals who use them and the work they do. An important phase of the work of manufacturing management is the selection, standardization, and procurement of the various physical factors, and their proper relation to the work of the organization. Training executives and operatives in the use of these factors never ends as long as the organization continues to progress.

The term "physical factors" may include any physical implementation of

[1] This was noted briefly in Chapter 3. The relation of physical to other business factors was shown in Fig. 2.1.

the performance of business functions. The term therefore includes such factors as plant location, the product, physical plant, production and office equipment, tooling, materials handling equipment, physical facilities for light, heat and power, and many others. Some of the more important factors will be discussed in later chapters.

The Importance of Proper Plant Location

Plant location is discussed at this point for a number of reasons. A decision concerning it, when we are expanding, may be necessary before we can make decisions concerning other major factors. Plant location is a factor that should receive early consideration in any plan for decentralization. Such a plan is usually a part of our long-range growth plans. Decisions concerning new locations and new plant usually involve large sums of money. Important financial problems may be raised accordingly. There may be problems of community and labor relations when a move to a new location is to be made in the near future. These are decisions that must be made initially by top management in connection with administrative planning for the growth and development of the company. Operative planning for the use of the various physical factors in production is conditioned by them.

The location of the plant is often an important factor in success or failure. On it may depend the company's ability to serve customers satisfactorily, to obtain an adequate and continuous supply of raw material at minimum cost, and to maintain a sufficient and competent labor force. Sometimes a poorly managed plant is able to enjoy a considerable measure of success because of a good location, whereas a well-managed plant in a poor location has difficulty in competing in certain markets.

Although a manufacturer may be operating successfully in his present location, he has no assurance that he will not be faced with the problem of selecting a new plant site at some time in the future. Habits and customs, centers of population and trade, channels of communication and transportation are constantly changing. The manufacturer may find, in 10 or 20 years, that his plant is no longer in an economical location. When the problem arises, the manufacturer will discover that the selection of a proper location involves a number of economic factors, some of which are rather intangible.

Primary Factors in Plant Location

There is always a question concerning what weight should be attached to the various factors in plant location. What factors should be given

primary consideration in the particular problem, and what should be given secondary consideration? This distinction, when made, will affect the decision concerning what is the best location for the proposed new plant. There are a great many location factors that can affect the decision.[2] Their importance varies between companies and industries. It may help to note again the primary mission of a manufacturing organization: the production and distribution of customer values of the kind and quality desired, when and where they are wanted, at a price that the customer will pay, and at a cost that will leave us with a reasonable profit. It would seem that the primary location factors are those that affect directly the accomplishment of the primary mission of customer service. The secondary factors are likely to be those that affect our collateral and secondary objectives. The following are more likely to be primary location factors, on this basis: (1) the location of the market, relative to the proposed plant site; (2) the location of raw materials sources; (3) availability of adequate transportation facilities; (4) the kind, quality, and amount of the available labor supply; and (5) the amount, reliability, and cost of available power.

The proximity of the site to markets may be very important in the case of small concerns that fill a local or emergency demand. Ice cream plants are located in or near the cities that they supply. A machine repair shop must be located near the industries that it expects to serve; in addition, there must be a sufficient number of plants that will need outside repair service. Companies that supply more than the local demand may find it advisable to give the market factor first consideration in selecting sites for branch plants. Nearness to their principal markets will increase the promptness with which they can serve their customers. If the cost of shipping the finished product is greater than that of shipping the raw material, nearness to markets may effect considerable savings in transportation charges. The desire of buyers to inspect and choose goods in large buying centers makes it advisable for dress manufacturers to locate near such centers. This is said to be one of the factors which has retarded the growth of the cloak and suit industry outside of New York City. In general, it is natural for an industry to locate near a market; and where

[2] The American Gas and Electric Company, in an advertisement in the *Wall Street Journal* of March 17, 1954, gave the following check list of plant location factors: access to markets, power, labor, water, living conditions, fuel, transportation, climate, access to seaports and lake ports, minerals, recreation, forestry, distribution facilities, reasonable tax rates. The company regards these as major location factors, presumably, since it has a profit interest in getting new industries into its territories. The factors that it did not list include: access to raw materials in addition to minerals, availability of land for expansion, construction costs, availability of financing, presence of service industries, state laws including labor legislation, waste disposal, national defense, and last but not least, the boss's wife.

there are several markets, the selection of the proper location, in so far as the market factor is concerned, is a matter of balancing against one another such considerations as population, purchasing power, and buying habits.

In many industries the relation of the site to supplies of raw materials may be the dominant factor in plant location. If the raw material is costly, heavy, or bulky, it may be more economical to ship the finished product a longer distance to the market than to ship the raw material to the plant. The farther the site from the sources of materials, the larger are the reserve stocks of material that must be maintained. Hence more capital is tied up, interest charges on raw material inventories are larger, greater storage space is required, and handling charges may be increased. In addition, there is the danger that the arrival of materials at the plant may be held up by transportation difficulties, with consequent losses due to interruptions of plant operations. However, the influence of the availability of raw materials may be modified considerably by other economic factors. For example, as the direct material cost decreases in proportion to the total cost of the product, the importance of the materials factor decreases, although not necessarily at the same rate. Thus the great sawmills necessarily follow the receding forests, but iron ore is shipped many hundreds of miles by water or rail.

Other things being equal, the best location, from the standpoint of transportation, is where the cost of moving raw and worked materials to and from the plant is at a minimum. It has been previously pointed out that transportation costs and services may be an important factor in the decision to locate the plant near the source of raw materials or near the markets. Cities which are served by a number of railroads sometimes have more favorable tariffs and provide better service than those which have only a single road. The manufacturer who is located in the latter may find that his transportation costs are as high as, if not higher than, those of his competitor in the railroad center, and that he has greater difficulty in getting cars when there is a shortage. In addition to offering choices of routings for incoming and outgoing shipments, many cities with several railroads have belt-line railroads connecting the principal roads. A car loaded at a plant on the belt line can be switched to any road in the city. This reduces transportation costs because of the greater facility in loading and unloading cars and the elimination of trucking to the siding of the particular road over which the shipment is routed. In large railroad and industrial centers, sites near these belt lines are very desirable and sell at high prices. Some in Cleveland are reported to be valued at $50,000 or

more per acre. The junction points of railways and waterways often offer desirable market opportunities as well as transportation facilities. Obviously, if transportation is a small part of the total cost of the product, the importance of locating near either the source of raw materials or the markets will be greatly diminished. These and similar considerations must be weighed when the transportation factor is evaluated.

The character of the labor supply may affect the selection of a site in a number of ways. If wage rates are high, labor costs may be high also. If the labor which must be used is unionized to a great extent, *per capita* production may be low, because of featherbedding and other practices. On the other hand, industries that otherwise are located disadvantageously sometimes operate successfully in the localities in which they developed originally, because of their employees' skill and familiarity with the work. Skilled workers, accustomed to earning good wages, cannot be shifted easily from one place to another; many own their homes and have established other ties that bind them to that particular community.[8] An important consideration is the adequacy of the labor supply—the extent, kind, and character—to meet varying production demands. This involves the amount of training, housing, and other employee service work that must be undertaken. In some industries, such as the high-grade furniture industry, this may be the most important factor in the location of the plant.

For the majority of industries, power costs are a major factor in plant location. Cheap power often attracts industries, particularly those in which this cost is an important element in the total cost of manufacturing. There are several large electrochemical plants near Niagara Falls because of the availability of relatively cheap electric power; and this factor has been important in building up the Pittsburgh manufacturing district. With the growth of large central stations and the development of superpower projects, an increasing number of concerns are finding it more economical to purchase rather than produce power. The operation of a power plant involves a heavy investment in equipment, and fixed charges that must be met whether the concern is producing or idle. When power is purchased, its cost fluctuates more closely with fluctuations in the volume of production. Whether it is more economical to purchase or produce power depends to a large extent on the size of the plant, the nature of the product,

[8] The Hat Corporation of America suffered a strike, in July, 1953, by Local 15 of the United Hatters, Cap and Millinery Workers International Union, to prevent the corporation from moving part of its operations from Norwalk, Conn., to a location that was considered to be more economical. The case got into the state courts. The union lost a ten-months strike, and more than $1,200,000. (See the *Wall Street Journal*, issues of 2/15/54 and 5/24/54.) Other companies, however, have worked out satisfactory arrangements for decentralization with union representatives of their employees.

and the quality and cost of local power service. Industries that use large quantities of steam, as in the manufacture of rayon, often find it more economical to generate their own power.

Secondary Factors in Plant Location

Other factors also affect plant location. Although, in general, they may be regarded as secondary, they may prove of prime importance in an individual case. Some of the more important are: (1) the cost of land and buildings, (2) the possibility for expansion, (3) the presence of service industries, (4) financial facilities, (5) water supply, (6) water and tax rates, and (7) labor legislation.

The cost of land and building varies greatly between manufacturing communities. Desirable sites range in price from a few hundred dollars per acre in the smaller towns and cities, to many thousands per acre in large cities. In the latter the cost of erecting factory buildings may be high. If land is reasonably cheap, sufficient acreage can be acquired for projected expansion. Buildings can be located in proper relation to one another to facilitate maximum production. These buildings can be constructed to meet the needs of the particular business. On the other hand, if land is very valuable, the cost of sites for certain types of construction, such as single-story sawtooth buildings, may be prohibitive. Furthermore, the interest charges and taxes on land and buildings are often an important item in the indirect expense of manufacturing.

A related consideration is the availability of land for expansion. If a business prospers, it may eventually become necessary to erect more buildings or to add to existing ones. If new buildings have to be located at some distance from the plant, administrative difficulties arise.

The presence of service industries may be important to some plants, particularly the smaller ones. If a plant is not self-contained, it may require the services of jobbing foundries, machine shops, parts manufacturers, public warehouses, and various services agencies.

The willingness and ability of the community to coöperate in financing the activities of the company may contribute materially to its success; hence the strength, progressiveness, and far-sightedness of the community become important factors. To some industries which use large amounts of water in the generation of power or in industrial processes, the nature of the water supply and water rates may be important. Because taxes have mounted rapidly in recent years and have become a serious burden on manufacturing operations, the tax rates and their application must be investigated in selecting a plant site. In some instances state labor laws

may be a factor. For example, many of the southern states have attracted plants from the north because their factory laws relieve the manufacturer of certain expensive regulations.

Classes of Plant Sites

Plant sites may usually be grouped in four classes: those located in (1) large, (2) small, (3) suburban, or (4) specialized manufacturing communities. The last named is really a special case of the other three.

LARGE MANUFACTURING COMMUNITIES

Large manufacturing centers, such as Buffalo, Chicago, Cleveland, Detroit, and Philadelphia have many manufacturing advantages to offer. In general, they afford excellent transportation facilities, for they are served by a number of competing railroads which in many cases are connected by belt lines. Moreover, such cities usually have an abundant supply of all classes of labor. One of the greatest difficulties in building an organization is securing sufficient minor executives and skilled labor. Such help can generally be secured in the city on relatively short notice. Furthermore, the labor supply is constantly fed by the urban trade schools and technical high schools. These large centers provide discussion groups —such as the sales, production, and employment managers' groups—which often are organized and conducted under the auspices of the local chamber of commerce. Such groups have a stimulating effect on executives and aid in their development. The large manufacturing community is well equipped with theaters and other amusement places. Its recreational and educational advantages are such that personnel work along this line is reduced to a minimum. Often it provides a good market for the product, particularly in the case of the small plant. It is well supplied with service organizations of the kind which have been mentioned above. Power can usually be purchased from central stations at reasonable cost—another distinct advantage for the small plant. Finally, the large city offers superior financial resources and services.

Against these advantages must be set a number of disadvantages of sufficient importance to induce many manufacturers to move their plants from the larger to the smaller manufacturing communities or to establish branch plants in them. In the large cities, land is expensive and the number of desirable sites is limited, making expansion of the plant difficult. Taxes are relatively high. The cost of living usually is higher than in the small town, and wage rates are correspondingly higher. The labor situation in certain trades may be greatly influenced by powerful labor unions.

If this is true of the particular trades which a plant needs, there is the possibility of lower *per capita* production and labor unrest. The presence of small loft concerns in the same industry may disorganize local markets and the labor situation in the city. The distance which urban workers must travel to and from their work is great. A site which is suitable in other respects may be so far from a car or bus line and from the working-class residential districts that it will be difficult to maintain a labor force. Many manufacturers feel that the appearance of their grounds and buildings is a good advertisement, as well as a factor making for good employee morale; the closely built industrial districts of large cities offer little opportunity for beautifying the plant and its surroundings. The beautiful grounds of the National Lamp Works' laboratory at Nela Park, on the outskirts of Cleveland, offer a striking contrast to the appearance of many plants in the city itself.

SMALL MANUFACTURING COMMUNITIES

The manufacturer in the small community has many advantages not enjoyed by the city manufacturer. For example, labor conditions are often better. A larger percentage of employees own their own homes and are permanently attached to the community. Often they can enjoy a higher standard of living on a lower wage level, because of lower living costs. In many cases the plant is a dominant factor in the life of the community. Plant executives may be able to enjoy closer and more cordial relations with the working force, for this reason.

Since land is usually cheaper and construction costs and taxes are lower, sufficient land can be secured easily for present and future needs. The small town or city often has a highly developed community spirit, and to encourage manufacturers to locate there it will offer such inducements as a free factory site or rebates of taxes. Its chamber of commerce may sponsor the sale of the company's securities in the community and induce local banking interests to finance the construction of a plant and the operations of the new concern. Such inducements are tempting, particularly to the firm which is not strong financially. These inducements may cause the improper location of the plant, however.

Opposed to the advantages of the small community, however, there are a number of disadvantages. If the company must build up its working force by bringing in workmen from other communities, it may be difficult to maintain an adequate force. In some instances, particularly in the company-owned towns of large corporations, it has been necessary to establish company schools and to engage in other educational activities,

for the majority of the better workmen want proper educational facilities for their children. Educational and amusement facilities may be limited, and considerable expenditures may be needed for them. Employees who have been brought in from a city may miss its environment and facilities. Important executives with large salaries may feel the absence of social advantages. This may make it difficult to retain them.

The small manufacturing community may not have a sufficiently broad labor market to provide an adequate supply of all kinds of labor on short notice. If workers are imported in large numbers, housing problems may arise. A considerable investment in workers' homes may be necessary before a large permanent increase in the working force can be made. Furthermore, the small manufacturing community may be less desirable because of inferior transportation facilities, the absence of a local market for the product, and the lack of other advantages that the city can offer.

A different type of small manufacturing community has developed since World War II. It has been called an "industrial district." There are said to be more than 100 such districts today, and the number is growing. Such a community may be near a large city, but it is not a suburban manufacturing community, in the usual sense of the term. It usually is not a specialized manufacturing community. The industrial district is a new community in most cases. Admission to it may be restricted to assure good living and manufacturing conditions. It may have been developed by the industrial department of a railroad company, for the purpose of getting more freight traffic. It may have been developed by a large real estate operator for the purpose of making a profit from the sale of land. The primary reason for such a district is the one that induces a manufacturer to move into it: it is a new, ideal manufacturing community that combines many advantages of a small community, with some access to the advantages of the urban community. It tries to minimize the disadvantages of both.

SUBURBAN LOCATIONS

Suburban locations also combine some of the advantages of the small community and the city, without their disadvantages. Suburban manufacturers are able to draw on the neighboring city for labor. Since their employees are thus able to enjoy better living conditions, they are probably more contented and stable. Educational facilities usually are good, and the employees can avail themselves of the amusement facilities in the city. The transportation facilities of many suburbs are nearly as good as those of the city. While wage rates and construction costs may

not be much lower than they are in the city, land costs and tax rates usually are. The more important executives can live in or near the city and thus enjoy its social advantages. For these reasons the suburban manufacturing community has been coming into favor.

SPECIALIZED MANUFACTURING COMMUNITIES

Although other goods are also produced, certain cities have become noted for certain kinds of manufactures—Akron for its rubber products; Detroit for automobiles; Grand Rapids for furniture; Battle Creek for breakfast foods.

These communities have certain advantages, peculiar to themselves, which make it advisable to consider them separately. For example, they may have an abundant supply of labor that is skilled in the processes of a particular industry. This supply may be augmented continually by the trade schools in the community. As a result, the amount of training which the individual concern must provide is reduced. Because of the large number of concerns in the same industry, dealers in materials and supplies can carry larger and more varied stocks, thus making it possible for the purchasing department to obtain necessary supplies on short notice from local sources. For the same reason, the specialized community is probably well equipped with various service organizations peculiar to the industry. Similarly, it may be easier to finance operations because local bankers are thoroughly familiar with the needs of the industry, and a new concern will probably find it easier to dispose of its securities because local investors have the confidence born of other companies' previous successes. Finally, the fact that the concern is located in a city noted for the products it intends to manufacture gives it a certain prestige, for the city's reputation in the field attracts buyers from long distances and results in a desirable local market.

Relative Advantages of Locations

The relative advantages of the different locations which have been discussed depend largely on the particular concern. In general, the large company which is more self-contained as regards operations can settle in the small community to better advantage than can the small concern. For the small plant, on the other hand, the city, with its varied service organizations, excellent educational and amusement facilities, broad local markets, good labor supplies, cheap power, and other similar advantages, is often better.

Determining the Plant Location

The modern manufacturer who finds it necessary to relocate his plant or to establish a branch plant has a number of sources of information to aid him. In addition to the numerous books and articles on the subject, census reports and various reports of the Department of Commerce are helpful. Many chambers of commerce in manufacturing communities maintain industrial bureaus which furnish information on the economic advantages of their particular community. The industrial agents of railroads and electric power companies are glad to give similar information in relation to their fields. There are also a few consultants who specialize along this line.

In general, the method of determining the best plant site involves the evaluation of certain physical and human factors which are conditioned by plant location. The objective is to determine the relative effects of these factors on the economy and effectiveness with which the various business functions can be performed. However, some of these factors are intangible, and an accurate objective evaluation of some of the others is difficult. The best available data on taxes, labor, freight charges, and other cost factors should be collected for each locality under consideration. A detailed cost estimate should be made for each of the principal products at each site. Other things being equal, the site which makes possible the lowest unit cost is the one that should be chosen. But since other things usually are not equal, the final decision may depend on a qualitative evaluation of the intangible factors.

The Decentralization of Industry

The problem of plant location is of great current interest because of the trend toward decentralization of manufacturing operations. There are several reasons for the trend, in addition to the desire of some industries to locate where wage rates and state labor laws are favorable. Functional decentralization, due to business growth, may require new organizational divisions of the business. A policy of product diversification also may result in decentralization. These developments may require the physical dispersion of manufacturing and sales activities on a geographical basis. Large organizations that are concentrated in a single locality are more vulnerable to attack by political and labor leaders. This is more true when these concerns are engaged in continuous manufacturing, because of the high concentration of capital that is required. A number of small plants located strategically around the country may be able to serve the public

more effectively than a single large plant. There are other reasons for the interest in decentralization, both functional and geographical. Most of them have been discussed previously.

There has also been some governmental pressure in recent years to accelerate the decentralization of industry. Our industrial potential is an important part of our military strength. It will probably be too late to decentralize when war starts, under conditions of atomic warfare. Policies for guiding the planning for decentralization for defense purposes have been announced.[4] Industry has been unable to coöperate rapidly, in many cases, because it may be locked into its present location by a heavy investment. There may be other reasons.

PROBLEMS

1. A prominent manufacturer of automatic washing machines and automatic ironers, located in southwestern Michigan, was considering expansion of his production capacity by building a separate installation devoted to production of the automatic ironing units. The company did not wish to increase its capacity in its present location because it was already the dominant manufacturing firm in a community of approximately 50,000 population. It had under consideration two possible sites. One was located in a city of 20,000 population in north central Ohio; the other was located in a community of about 5000 located in northern Mississippi. Wage levels in the Ohio area were approximately equal to those in the Michigan plant, and approximately 15% lower in the Mississippi area. Civic leaders of the Mississippi area offered a site, located on the edge of the city, on a tax-free basis for the first 5 years. Freight transportation between the Michigan plant and a plant on the Mississippi site would be approximately 7% higher than that between the plant and the Ohio site. The Mississippi site offered room for later expansion up to 20% more than the present site. Further expansion would necessitate buying up additional houses and lots located on surrounding land. The Ohio location offered indefinite expansion possibilities.
   (a) What additional facts would you need, concerning what plant location factors, before you could make a recommendation to the company's management concerning a choice between the two sites?
   (b) Where and how would you get this information?
   (c) Cite the plant location principles that would support your request for additional time and money for fact-finding purposes.

[4] The difficulty with any governmental leadership in any economic activity is that it tends to be political. The particular governmental agency usually must depend on the voluntary regional coöperation of special group interests, as it should. Its policies may be influenced by political as well as economic considerations in consequence, however.

CHAPTER 9 •

• Product and Process Planning

Creative Planning and Design

IT was noted earlier that the process of business planning begins with the determination of business objectives. It proceeds from them to the solution of more specific problems. These basic generalizations underlie the planning both of the product and of the processes by which it is to be manufactured.

Industrial design involves chiefly the determination of how certain form utilities shall be created in the particular goods or services that the industry produces. These utilities must enable the public to enjoy the kind, quantity, and quality of satisfactions it desires at a price that it is willing and able to pay. Otherwise the concern may not obtain the volume of business necessary for profitable operation. These values constitute the company's primary service objectives. The requirements for a satisfactory accomplishment of these objectives, in terms of quantity, quality, time, and expense, must be known. This knowledge is the basis of an intelligent approach to the solution of design problems. The engineering design functions accordingly make use of facts developed by marketing and industrial research.

There are two major industrial design functions, product design and process design. Product design determines what attributes the finished product should have to enable it to give the required customer service. Process design determines the methods and conditions that are required to make a product that has these attributes. Both design functions must be realistic in dealing with the requirements of quantity, time, and cost. Both functions result in or affect the determination of all basic types of business standards in a manufacturing enterprise. These functions therefore affect all classes of management decisions, directly or indirectly.

The Relations Between Design and the Line Functions

It may be helpful to review briefly the relationships that should exist between the function of design and the primary line functions of a manufacturing concern. Design is a technical staff function. It develops by evolution from the functions of the line organization to which it is attached. Its purpose is to render either specialized assistance in the creative planning of product or process, or some related service of facilitation to this line organization, and to other groups, as required. Many small manufacturing concerns cannot afford an expensive staff of specialists in product and process design. The line executives confer with one another on what changes should be made in their products, usually on the basis of customer or dealer complaints, and what improvements should be introduced in their manufacturing methods. Its administrative officers may authorize the limited use of a consulting service to obtain not only some of the advantages of specialization but an outside point of view. As the company grows, technical staff units for product and process design will begin to appear.

A technical staff executive works normally through the line executives rather than over them. He may be in direct contact with line functions, but he does not usually have direct authority and control over them. This is the relationship that usually exists between the design functions and the line functions in the sales, financial, and manufacturing divisions. For example, in a plant which makes an assembled product, the engineering division may work out an improved design for a particular component part, but in most cases it cannot order the production division to discontinue the old part on a given date and to manufacture thereafter on the basis of the new design. Before such an order can be issued, questions concerning the inventory of the superseded part on hand, current orders that must be serviced, changes in the operation list for the new part, etc., must be answered. The engineer's recommendation must have usually the concurrence of designated product and production coördination committees. The recommendations must be approved by the head of the manufacturing division before it can acquire line authority. Further approval by higher authority may be required. Changes in product or process are very expensive. Most concerns find it more economical to hold such improvements until these changes can be integrated in the annual new models.

It is evident that some arrangements, both organizational and procedural, must be provided for coördinating the work of engineering

design groups with the work of other departments and divisions. The level at which coördination should be accomplished depends on the scope of the decisions that must be made. We have seen that a major problem of new product development may affect all major divisions of the business. Coördination should be accomplished, in such case, under the general direction of the executive vice-president, or the president. This would probably be the case in the company in Fig. 6.1. The formal coördination of action, leading to plans development and execution, would be accomplished by the vice-president, administrative staff services. Similar coördination of design problems of intradivisional or intraplant nature would be accomplished by corresponding groups on these levels. The coördination of thought in the work of planning may be accomplished by product or production committees, and by the technical staff department that is principally responsible for the solution of the problem. There are only three ways in which coördination can take place: direct personal coördination by a line superior, staff coördination, and cross-coördination through direct contacts between the subordinate line and staff executives whose functions are affected. The general outlines of the procedure for engineering coördination will be discussed later.

Product Design

Product design is that phase of creative planning in manufacturing that has to do with the determination of the attributes of the finished product. Its objective is a relation of product elements and their functions that will assure to the customer the particular satisfactions that he desires from such a product. What these values are depends on the services that the product is expected to render. For example, the housewife who buys a kitchen stove usually wants one that will enable her to produce the best cooking of which she is capable, and will relieve her of as much physical labor as possible. She wishes in addition to avoid the physical discomfort of working in an overheated kitchen. She desires also a stove that has some beauty, that harmonizes with the other appointments of her kitchen, and that she can show to her friends with a feeling of pride. She is responsible for the household budget in most families. She is also interested, accordingly, in the economy of operation of the stove as well as its original cost. If the stove manufacturer is to enjoy her patronage, his designers must so plan the stove that it will have the requisite utilities so that it will provide the various satisfactions that she desires. Thus the oven should have accurate temperature control, it should maintain heat at a constant level, and it should be insulated properly so that it will retain heat instead

of transmitting it to the surrounding atmosphere. Ease and speed in cleaning the stove are important. It must be possible to get at the various parts with a minimum of disassembly and lifting. It must have the proportions and finish that will appeal to the housewife.

The utility of a manufactured product is determined largely by the attributes of its component parts. It is determined also by the relations between these parts and their functions. These attributes may be such qualities as form, dimension, chemical composition, weight, color, finish, or any other quality characteristics that determine significantly the utility of the product. What properties, for example, should an insulating material have to be suitable for the oven? What kind of material does this indicate? What problems are involved in using it under present manufacturing conditions? How should it be set in? What thickness should be specified? These and other similar questions must be answered and reduced to objective terms in the form of mechanical drawings and product specifications. A simplified example of dimension specification on a mechanical drawing is shown in Fig. 18.7.

The problem of product design in most products today can be broken down into two general phases: the mechanics of design and the aesthetics of design. The term "mechanics of design" refers to that phase of product design which has to do with the product's utilization of physical forces or with the properties of materials, in the performance of its functions. The various parts of an automobile motor must be made of the right materials and properly proportioned and related if the motor is to deliver the maximum power possible from the fuel it consumes. It must also give reliable service throughout the normal life of the car, even with hard use. This is a job for an engineer.

The aesthetics of design is concerned with certain aesthetic attributes of the product, such as mass, proportion, finish, color, etc., which enable the customer to enjoy certain feelings of beauty, fitness, strength, reliability, etc. It deals largely with his reactions to the appearance of the product. The aesthetic utilities of a product enable the customer to enjoy certain psychic satisfactions. Such satisfactions are values quite as much as any physical satisfactions that he may obtain. An attempt to make the product more salable through proper attention to them is both worth while and desirable. The rapid rise of the industrial or style designer in recent years is evidence of this fact.

There are a great many important industries of a so-called "nonengineering" nature, such as printing, clothing manufacturing, meat packing, shoe manufacturing, etc. For the most part, the distinction between the

creative planning of product and of process holds for them, as well as for industries making a complex mechanical or electrical product. The engineering departments of the latter have reached a high point of development. We shall use them as examples for this reason. The same fundamentals may be applied in some degree and manner in most manufacturing industries, even though the details may not.

New Product Development

The initial phases of new product development were discussed in connection with the marketing function. The problem begins frequently in the marketing and financial fields. There is no point in designing a new product for which no customer has any need. It must be possible, of course, to establish a good competitive position for the proposed product within a reasonable period of time. It is hardly worth while to design a new product that cannot be manufactured and sold at a satisfactory profit. These are basically economic rather than engineering questions.

New product development can begin, however, in research labortories with tests of competitive products to establish their relative quality ratings.[1] It can begin when some scientist or research engineer gets a new product idea. A research project may be authorized, and a budget allocation made, if the idea looks promising. The laboratory can then investigate the principles that must be applied in the proposed product to give the customer the new or improved service. It must go farther usually: it must also develop a laboratory model, or prototype. This model merely shows how the physical principles that have been developed by industrial research can be applied to the accomplishment of the customer service objectives which have been determined through marketing research. The prototype is not usually a salable product. It is not capable of giving the customer continuous service under the normal conditions of customer misuse. It may be that it could not be manufactured and sold at a price that the customer would pay. It is the staff responsibility of product design to plan a salable product that can be made economically. The design and development of the new product does not usually begin, however, until marketing and industrial research have developed the facts and principles on which design must rest.

[1] The evaluation of competitive products involves usually the application of some merit-rating technique to test results, see E. H. Hempel, *Top Management Planning*, Harper & Brothers, 1945, pp. 131-133. The general approach of merit rating has been applied also to materials and personnel.

A coffee mill is a common piece of equipment in grocery stores. The development of this product is illustrated in Fig. 9.4.

The Product Engineering Division

A salable product, that will meet the conditions of effective competition, is a primary factor in the accomplishment of the organization's primary service objectives. Its design involves consideration of many marketing, manufacturing, and financial problems, as noted above. The creative planning of product is consequently a primary technical staff function. Requests for new products to meet new needs, or new models of old products to serve new uses may come from a number of sources, in addition to customers and dealers. A design proposal may be originated when the request or suggestion appears to be feasible and any required research work has been completed satisfactorily. This proposal may go to a product committee composed of general executives, representing the principal divisions of the company. The proposal should be supported by adequate marketing, manufacturing, and financial data to show why and how the proposed product or new model will further the objectives of new product development. The product committee may reject the proposal, or recommend it to higher line authority for approval. The group of executives in Fig. 9.1, for example, is evidently considering certain product proposals from the viewpoint of general policy. The staff coördination and origination of the product proposal may be accomplished in Fig. 6.1 by the office of the vice-president for administrative staff services, because of the interdivisional nature of the problem. It may be a responsibility of the chief engineer in small companies. The approval of the proposal by higher line authority delegates authority to the engineering executive to commence design and incur the necessary expenses. It will be seen shortly that these expenses may be very great.

The engineering function can be developed in a growth industry through all the stages of staff evolution that were noted in Chapter 4. It will depend on the volume of business and size of the company, the technical complexity of the product, the rate of technological progress in the industry, and the state of quality competition, the degree of product standardization that has been developed, and similar considerations. The company in Fig. 6.1 has a director of engineering and research. He is on the level of general administrative management, as shown. His office coördinates the work of the plants in the technical design and development of product. He may be the chairman of the product committee. He exercises a leadership of ideas in the formulation of general engineering

Fig. 9.1. Top Management Planning of New Product. (Courtesy, Diamond T Motor Car Co.)

policy for the company. He participates in long-range company planning with particular reference to technical developments that may affect new-product offerings and requirements for new facilities. He coördinates the solution of general management problems in the engineering field that must be handled at corporate headquarters.

The trend of thinking by American top management has been in the direction of decentralization and the development of the profit-center concept. This concept will be discussed briefly when the subject of finance is discussed. It is sufficient to note here the tendency to decentralize profit responsibility by product lines to the lowest possible level in the organization. This point is reached in the lowest organizational component in which total tangible assets can be segregated accurately by product lines. This component may be an operating division, or a plant within it. The intent is to make its executive head completely responsible for sales, manufacturing, and financial results for the product lines that have been assigned to him. This executive can be held completely accountable for results, since he has been given adequate authority, facilities, resources, and staff for the discharge of this respon-

sibility. It will be seen in Fig. 6.1 that the plant manager has a chief engineer, and probably for the above reason. The relations between the director of engineering and research and the plant chief engineer should be strictly staff. They should conform to the conditions of staff parallelism that were noted in Chapter 6.

The chief engineer should have good technical training and experience. Some production experience is desirable, inasmuch as he must understand the problems of the line executives if he is to work through them effectively. As the size of the concern and its volume of business increase, the scope and complexity of the engineering function also increase, as well as the number of people required for it. The head of the engineering division has less and less to do with the detailed work of design. His time must be spent in the administrative planning of the work of his division, in organizing and coördinating its activities. In a large engineering division, therefore, superior executive ability may be quite as important as superior technical ability. The managerial responsibilities of the engineering executive are suggested by the design office shown in Fig. 9.2.

Fig. 9.2. An Engineering Design Office. (Courtesy, Truck and Coach Division, The General Motors Corp.)

The product design function in a manufacturing company tends to break down into a number of distinct functions. This breakdown will vary in detail between industries and companies, depending on the objectives and requirements of the product. This variance may be quite substantial between companies in chemical process industries, such as Du Pont for example, and companies in industries making an assembled mechanical product, such as the Ford Motor Car Company. The objective of the function, in any case, is a plan for a product that will serve the public

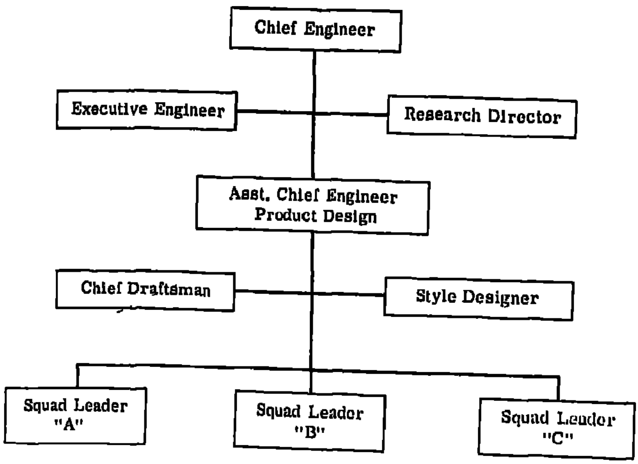


Fig. 9.3. A Product Engineering Organization

satisfactorily, in competition with like products. It must be possible, of course, to make this product at a cost that will permit a reasonable profit. The principal work of the engineering department therefore has to do with product planning and specification. A skeleton outline of a product engineering organization is shown in Fig. 9.3. It would be most suitable for the design of assembled mechanical products. It will be seen that the principal chain of command of this department extends from the chief engineer, through the assistant chief engineer and the squad leaders, to the product designers in each squad. The latter are professional operatives. This is not a primary chain of command, since engineering is a staff function. The values that it produces are basically informational; they are not directly salable to the customer. These are values that are needed by the line organization. The functions of the executive engineer, the research director, the chief draftsman, and the style designer, as shown in Fig. 9.3, are staff functions within the engineering department. The basis of functional similarity between functions assigned to the de-

partment is found in the similar scientific and engineering background, training, and experience that are required for the accomplishment of product engineering objectives. There are consequent likenesses in the personalities and abilities that are effective in performing engineering functions.

The Research Function

Industrial research is the function of investigating and analyzing scientifically the physical factors, forces, and effects that enter into the development of product and process, and the principles governing their relations. Its objectives are new facts concerning these physical factors and principles, and the requirements for their effective application. The significance of the function is indicated by its rapid growth in American industry. The median expenditures for research in 1940 were approximately 5 percent of gross sales for concerns capitalized at $75,000.00 or less. They were less than 1 percent of gross sales for concerns capitalized at $100 million and over.[2] There has been a steady increase in both the amount and percentage for industrial research since 1940. The percentage appears to have increased faster, in large companies, than the rate of growth of gross sales.[3] Reports in various business periodicals suggest that it is now between 2 and 5 percent of gross sales in our large concerns.

The research laboratory may have three distinct functions in manufacturing concerns: research, testing, and experimental engineering. The first phase, research, may be broken down into three subfunctions: pure research, product research, and process research. Pure research in industry is generally found only in the laboratories of large corporations. The scientists pictured in the rotogravure sections of the Sunday papers producing five-million-volt thunderbolts or something equally startling in the great laboratories of Westinghouse or General Electric are engaged in investigating electrical phenomena that underlie the construction and operation of electrical equipment. They hope to gain a greater understanding of the laws of electrical science, and to extend these laws, particularly as they relate to the design and production problems of the industry. Eventually, the factual data they develop will be put in a form that will permit its practical use by the company's designers.

Product research is concerned with the development of new uses for

[2] *Research—A National Resource,* Vol. II, p. 174., U.S. Government Printing Office, 1940. (A report of the National Research Council to the National Resources Planning Board.)

[3] See an article on "Rising Research" in the *Wall Street Journal* of April 26, 1954.

old products or new products for new needs. In so doing, it applies facts and principles that have been developed through pure research. The speed with which steel can be cut affects greatly the cost of machining steel parts. The Battelle Institute, for example, has developed, for a well-known steel manufacturer, a leaded steel in which high machinability is obtained without any sacrifice of other desirable attributes. It is one of the new products of the steel industry, and may revolutionize metalworking processes.

Process research is concerned with the development of new or improved production methods. The research of the American Rolling Mill Company that resulted in the development of the continuous rolling process is an example.

The testing function is concerned with the evaluation of the properties of materials and products to assure that they conform to whatever specifications have been set up for them. For example, a company's purchasing department may have contracted for many carloads of coal, covering its requirements for some time in the future and involving a large amount of money. The purchase order may specify the permissible content of ash, sulfur, moisture, etc., as well as the required heating value per pound. When a carload of coal arrives, the company naturally wants to be certain that it is getting what it contracted for. But the analysis of coal requires a scientific technique that can be applied only under laboratory conditions by trained technicians. Since the employees of the receiving department or the receiving inspection department have neither the ability nor the equipment to make the necessary tests, coal samples from the car will probably be sent to the testing section of the research laboratories for analysis. The testing sections of laboratories in the paint and varnish and other chemical process industries render a service in controlling the quality of work in process; in still other ways and in other industries the testing function makes important contributions, when laboratory facilities and abilities are required.

Experimental engineering is the function of checking the validity and accuracy of the designers' plans through building and testing experimental models. We shall not go into it at this point, since it will be discussed later in connection with the administrative control of product and process planning. It will be seen then that experimental engineering contributes greatly to the achievement of product design objectives.

It is apparent that industrial research serves chiefly staff functions, rather than line, in a manufacturing concern. Its position in the organization is that of a secondary technical staff function, when it is attached

to the chain of command of the engineering department or division. This would be an effective position in the company shown in Fig. 6.1, provided that the significance of the term "secondary technical staff" is understood. Responsibility for product design and development has been decentralized largely to the plant level. Otherwise, however, this position may underemphasize a function that has made great contributions to the rapid progress of American industry. Research may be differentiated completely from both the engineering and production functions in very large corporations. The General Motors Research Corporation, for example, is an independent entity, subject only to the general administrative policy and control of top management in the General Motors Corporation.

A product that can give the customer a unique or superior value at a competitive price is in a superior competitive position. The company that develops it may be able to get a better percentage of profit on sales as a result. A company that is a member of the "billion dollar club" may have an annual research budget of $20 million or more. It can afford to supply excellent laboratory facilities and highly competent research staff. The records of the U.S. Patent Office show that the companies taking out the largest number of patents annually are among our largest corporations. It is obvious that organized industrial research may give to the large concern a competitive advantage. This advantage should not be overemphasized, however. The small concern can make use of many university and private research facilities, on a contract basis. It may be able to manufacture new product innovations of the large corporations under a license from the holder of the patent. There are competent engineering consultants who will assist in product and process design. Trade associations sometimes engage in research, and make the results available to their members. There has been no reduction generally in the ratio of small to large manufacturing concerns for these and other reasons. There has been a reduction, however, in specific industries requiring highly technical research and large amounts of capital.

Product Design Organization

Product design is a function of creative planning. It makes a technical determination and specification of the attributes that the product should have to enable it to supply the values required by the customer. These attributes may be expressed in the form of written specifications, sketches, or mechanical drawings in the case of a mechanical product. The quality of the service rendered by the finished product depends on the qualities of the various product elements. In the case of a mechanical product,

these elements are the component parts and subassemblies that make up the finished product. Certain qualities of some of these components may derive from certain properties of the material from which they are made. In consequence, the function of design includes the determination of the material to be used in making each component. Thought concerning design must necessarily begin with the requirements of the product's service objectives; the detailed work must end with a plan for their reasonable achievement.

Product design may be broken down into significant phases or subfunctions, like any other work. These phases must be differentiated increasingly as the organization increases in size. A number of design groups may report to the engineering executive who is responsible for design. This executive may have the title of product engineer or chief designer or assistant chief engineer as in Fig. 9.3. These groups usually represent the breakdown of design on the basis of the principal functional groups of parts or assemblies that make up the completed product. For example, in the familiar case of the automobile, there may be the chassis group, the engine group, the electrical units group, the body group, the final assembly group, etc., each headed by an engineer who is a specialist in that particular field of automotive design. In many concerns this man is called the "squad leader," Each group in turn may be broken down on the basis of its subfunctions, representing further specialization. For example, there may be a distinct differentiation of the carburetor design function within the engine group. It will probably be headed by an engineer, who is a highly trained specialist in this field. He may have one or more junior engineers working under his direction.

The downward growth of the product design function results in a definite hierarchy of responsibility and authority. It is the principal chain of command of the engineering division since it leads directly and immediately to the achievement of the department's principal objectives. For the most part, this is not true of the other elements of the engineering department. The values that they contribute enter into the accomplishment of engineering objectives, chiefly through the design group.

The Drafting Function

The drafting function has to do largely with routine design, and with putting the engineer's plans in a readily usable form. It may therefore be regarded as a staff phase of the product design function. In some concerns, draftsmen are directly attached to the various design groups and work under the direction of the squad leader. In many engineering depart-

ments, however, drafting has been differentiated completely from the product design functions, and has been organized as a central drafting service under the leadership of a chief draftsman. This makes possible the more economical use of the draftsmen's time, better service for units outside of the engineering department, greater uniformity of drafting practice, better training of beginners, etc.

The work of the drafting room may be broken down into three principal subfunctions: drafting, tracing, and checking. Drafting is primarily the function of empirical design. In most mechanisms there are many standard elements such as handwheels for the manual adjustment of a machine. They have been standardized by the company, or by some national engineering society. The tracing function has to do with transferring to tracing paper or transparent tracing cloth the engineer's plan for the part or product, in so far as it is shown on the drawing or sketch that he sends to the drafting room. Any number of blueprints can be made from this tracing, much as a photographic print is made from a negative. In this convenient and semipermanent form copies can be sent to everyone in the organization who has any legitimate use for them. Original drawings and tracings are extremely valuable, and are seldom permitted to leave the engineering department. The checking function is essentially one of inspection. The blueprint will show only what appears on the tracing. The production division has no authority to deviate from product specifications and blueprints. It is expected to make inquiries, of course, if it suspects that it has received incorrect information. Hence if a tracer leaves out a line, copies a dimension incorrectly, or makes some other error, it may carry through to the shop and cause losses running into large sums of money. To guard against such possibilities, a checker compares the finished tracing with the original drawing or sketch to make certain that no error has been made.

Style Design

We have noted previously that the aesthetics of design is concerned with certain aesthetic attributes of the product, such as mass, proportion, finish, color, etc.; that it deals largely with the customer's reactions to the appearance of the product. Its objective is a design that will enable the customer to enjoy whatever psychic satisfactions he deserves, such as a feeling of beauty, fitness, strength, or reliability. The function of planning the external attributes of the product so that it will have the desired aesthetic qualities is known in some concerns as style design.

The style designer has been placed in Fig. 9.3 in a secondary technical

staff position because mechanical products are being used as examples. Not all engineering departments have a style designer; but when there is one, he must work closely with and usually through the final assembly group under the product engineer. Style is important in many such products, but its contributions must be secondary to the proper mechanical functioning of the product. Style design should be differentiated completely from the other design functions in the engineering department. Its roots lie in the field of the fine arts, whereas engineering has its roots in the physical sciences. The style designer requires a background, training, and experience that are fundamentally different from those required of the engineer.

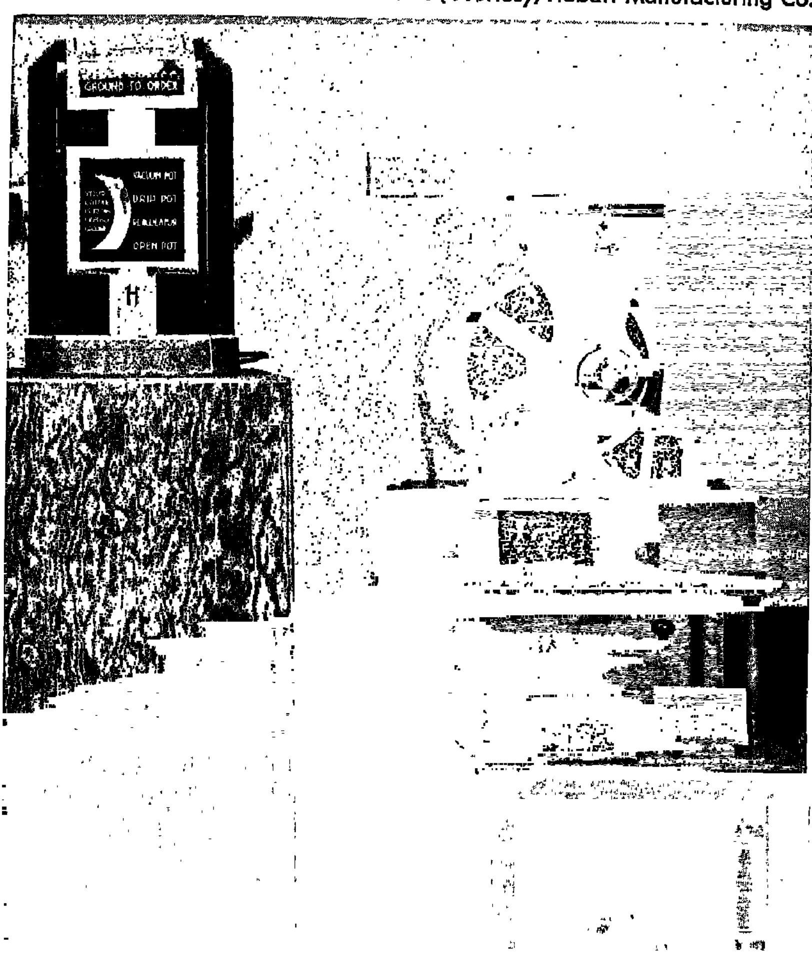
We have mentioned previously the many manufacturing industries, some of them highly important, that are often called "non-engineering." The aesthetics of design may be the principal design function in concerns in such industries, particularly when they manufacture so-called style goods. The mechanics of design occupies a distinctly secondary position, in such case.

Using the term "style" to cover all phases of the problem, we may break down the aesthetics of design into two chief phases; style design, which has to do with the styling of the product, and package design. The latter function is concerned with the styling of the container which carries the product to the public. Style design is not merely a device to exploit the gullible consumer. On the contrary, it serves the public's real need and desire for beauty and certain related psychic satisfactions. Style design could not have had its remarkable increase in importance in the world of manufacturing if this were not the case. Furthermore, this desire for beauty, distinctiveness, or what not, is not confined to certain types of shopping or specialty goods that obviously are affected by style. The hand-operated coffee grinder on the lower shelf of the right-hand stand in Fig. 9.4 is the type that our great-grandmothers used in Civil War days. In those days coffee enjoyment was not affected by the relative merits of the vacuum pot, drip pot, percolator, or open pot method. On the stand at the left is a coffee grinder of the type used by the modern grocer. Not only does it do a better job of grinding coffee, but it adds appreciably to the appearance of his store and to its attraction for customers. One would hesitate to accept the job of selling the old-fashioned power grinder to the grocery trade unless he were blessed with an independent income. Even in such industrial goods as machinery and equipment, it has been found that simplicity, beauty, and economy usually go together, and decrease sales resistance to the product.

In part, package design is also the result of the public's increasing demand for beauty and distinctiveness, as well as utility. A box, carton, or bag that merely conveys the product to the customer in good condition is not sufficient today; even common convenience goods that formerly were sold exclusively in bulk are now style-conscious. The label on a can of beans adds no succulence to the contents, but a housewife will usually select a can that is labeled attractively, in preference to one of the same price and quality that is not. Apparently she appreciates certain values that the container supplies over and above its contents.

If a concern creates too many models in an effort to satisfy the demand for style, the volume of business for certain of them may not be sufficient to permit economical operations. In many complicated mechanical products today, the customer has a considerable range of choice of style and

Fig. 9.4. The Evolution of the Coffee Mill. (Courtesy, Hobart Manufacturing Co.)



service features; the number of their possible combinations in the finished product is of course much greater. The basic mechanical features are usually standarized, and identical in each model of product, however. It is evident that this creates some problems in coördination for the production manager and his subordinates, particularly the manager of the final assembly plant. For example, a chassis on the final assembly conveyor of an automobile plant is tagged for a dealer in Boston who has indicated that he wants a green body on the car, the color specified by his customer. Obviously, if a red body is dropped on this chassis when it arrives at the body assembly station, the customer will not be satisfied; furthermore, green wheels must be hung on it at the wheel assembly station farther up the line. In general, the routinization of work tends to vary inversely with the trend toward greater styling. There may of course, be a considerable difference between the standardization of product and the routinization of work. The aesthetics of design has exerted a profound influence on economy in manufacturing. It is to the credit of the American manufacturer that he has been able to supply the public with a product that gives better service and looks better, and is in many instances priced lower.

Trends in Product Design

The field of product design is developing continuously. Some of the developments in engineering research and design have had some extensive effects on both operative and administrative management in the industrial organization. We have noted previously some of the effects of new product development, for example. There is in addition a continuous effort to simplify product designs and to develop interchangeability of parts between models and lines. This is due partly to a desire to improve our competitive position through better customer service, and partly to the necessity for cost reduction. New manufacturing methods are being developed continuously. It may be possible to build up a subassembly by welding parts together, rather than by the use of mechanical fastenings such as nuts and bolts. The decision concerning the method to be used will have quite an effect on the design of both the parts and the subassembly. New materials with new or improved properties are available to the designer. There is a trend toward product miniaturization particularly in the electronics field. R.C.A. has developed a walkie-talkie that has only half the size and weight of its World War II counterpart, but twice the range and other superior qualities. Miniaturization saves material, increases portability, and may reduce costs. There is a counter trend that might be called "giganticism": It is the trend toward improving

quality or reducing costs by making large parts in one piece, with one or a few operations, using gigantic machines. The design and development of the single-piece wing panel for an airplane is an example. This is all a part of the picture of technological progress. It has affected greatly the organization of the engineering department, and its work.

The Executive Engineer

As an organization grows the internal problems of control also increase, usually in geometrical progression. The increasing need of coördination makes it necessary, sooner or later, for the responsible executive to delegate some of the details of control to subordinates. This is usually the beginning of the evolution of a coördinative staff function. It may occur in either a primary line or a staff organization.

The executive engineer assists the chief engineer and other engineering executives in the control of the department's work. He may act also as a liaison officer between engineering and the other divisions of the company, notably the sales, legal, comptroller's, purchasing, industrial engineering, and production divisions. He has a staff responsibility for the coördination of action in the execution of product design projects. He is subject to general direction by the chief engineer.

The functions which come under the jurisdiction of the executive engineer vary with each concern. It is probable that he will be responsible for the engineering department's vault in which are stored the original drawings and tracings, on which may depend patent rights worth millions of dollars. Their receipt must be recorded accurately; their withdrawal is usually closely restricted. As a rule, this executive is also responsible for the blueprint room, engineering records, specification files, etc. He may supervise a group that is preparing product information in nontechnical terms for the sales and advertising departments. All bills of materials, blueprints, and other product information usually must be released through his office. To control such releases, his signature will probably be required on all engineering release notices inasmuch as he acts as the chief engineer's executive officer.

Production control begins in the engineering department in some concerns manufacturing heavy producers' goods to the customer's specifications. Completion of the order may require a year or more of shop production time. A specified delivery may be a condition of the purchase contract, nevertheless. It may not be possible for the shop production departments to make up the time lost when the engineering department fails to complete its design work as scheduled. It may be the responsibility of the

executive engineer, in such case, to set up and operate a control system to assure that the work of design progresses as scheduled. The general approach to this problem is simple: an order of design is established for each part, subassembly, and assembly composing the product. The work of designing each part is broken down into its principal phases. Terminal dates, or "deadlines," are set for the completion of each phase of each part. A squad leader is probably responsible for the design of the subassembly that includes the particular part. An agreement concerning the required design time for the part is reached between him and the person in the executive engineer's office who is responsible for engineering progress control. The squad leader merely reports weekly the estimated design time required to complete the current phase of each design project in progress in his group. The first phase of the design of part X, for example, may be the study of the project. We shall assume that 10 days has been allowed for this phase. The design progress record for the part shows that 9 days have been spent on this part to date. A report from the squad leader in charge of the design shows that 3 more days probably will be required to complete it. We have spent 90 percent of the scheduled time allowed and have accomplished only 70 percent of the work. It is obvious that we have lost 2 days already. It must be picked up by the designer, if possible, in the later phases of the design. It is evident also that there should be some control of design work load, relative to the design capacity of each squad.

The executive engineer makes an important contribution to the smooth operation of the engineering department. It depends much more on his executive ability than on his technical knowledge.

Process Design

Process design also is a phase of creative planning. It has to do with the determination of the characteristics of and relations between methods used in manufacturing a product and its component parts. Whereas product design deals primarily with what the product shall be, process design is chiefly concerned with how it shall be made. Figure 1.2 showed a simple illustration of the principle of a drill jig. Some product designer must have determined the length, width, and thickness of the plate to be drilled, as well as the material from which it is to be made. In addition, he probably determined the degree of accuracy necessary for these dimensions. On his drawing he showed the exact location and dimensions of the hole in the plate. But this was probably as far as he could go, because the determination of how this hole is to be made requires more practical

manufacturing experience than a designer has as a rule. This hole could be bored by setting it up in a milling machine, or in a lathe with a special fixture, or in a horizontal boring mill, or in a vertical turret lathe; it could be broached if necessary, or some other device for making a hole could be used.[4] The final decision to use a drill press probably was made by someone familiar with the industry and its manufacturing methods. This expert took into account the degree of quality possible with each type of equipment in relation to the quality specified, the time required to set up and adjust each type, the quantity of parts to be run in a lot, and other similar considerations that enter into economy in manufacturing. The objective of process design is a plan for making each part and assembly in a product that will enable the shop to produce it economically and effectively. Such a plan is shown in Fig. 9.5.

In small concerns, the process design function may be handled by the line executives of the manufacturing division. Inasmuch as practical experience plays an important part, they may do a very good job. Increasing specialization of mechanical functions occurs as the volume of production increases with the growth of business. This adds to the complexity of process planning and facilitation. It becomes desirable at various stages in the organization's growth to differentiate distinctly the principal phases of the process design function from the line functions of production, in order to permit specialization in their performance. In large concerns these phases may be completely differentiated from the line organization and brought together in a major technical staff department or division such as is shown in Fig. 9.6. This does not occur usually until long after the product design functions have been completely differentiated. We shall discuss the process design functions briefly as they may be grouped in a plant manufacturing an assembled product. This type of industry was used in the discussion of product design. Its continued use will make it easier to relate the two functions. Analogous process design functions will be found in any industry, however. The work content of the functions will differ between concerns with the type of industry and the nature of

[4] What are a milling machine, a horizontal boring mill, a vertical turret lathe, etc.? We need know only that they are different types of machine tools that may be used in a metalworking concern to make holes in metal. One might never hear of them in the publishing business, clothing, shoe manufacturing, etc., where quite different types of equipment are used. Although valuable help may be obtained from books and school shops, practical experience is generally the best means of learning what machine can be used for certain mechanical functions in a particular industry, and what the probable results will be. It should be remembered also that general-purpose equipment is related to but different from production equipment of the same general kind. If the reader is particularly interested in drilling machines, he can see a drill press in Fig. 11.3, and a gang drill in Fig. 14.4.

WORK SIMPLIFICATION CHECK LIST

MATERIAL

1. Can cheaper material be used without impairing quality?
2. Can lighter gage material be used advantageously? Heavier?
3. Can part be made from offal?
4. Can standard stock parts be purchased?
5. Can some use be found for scrap and rejected parts?
6. Is it received in the most economical length? Size? Weight? Shape? Finish?
7. Is it utilized to the fullest extent?
8. Should we change from "make" to "buy", or from "buy" to "make"?

DESIGN

1. Can part be eliminated completely? Partly?
2. Will it help to change tolerances? Specifications?
3. Can it be changed to make fabrication easier? Cheaper? Reduce scrap?

SEQUENCE

1. Is every operation necessary? Can part of it be eliminated?
2. Is every operation performed at the right time? Place? In the right way?
3. Is plant layout the best that can be obtained?
4. Can operations be combined? Separated?
5. Is it economical to use conveyors to move materials?
6. Would change in lot size help?
7. Can inspection be made a part of operation?
8. Can operations be performed while material is in transit?

TOOLS, GAGES, EQUIPMENT AND WORKPLACE

1. Is machine the best type for the job? Can it be improved? Is it in good condition?
2. Is it running at the right speed?
3. Would it be economical to make it automatic?
4. Are the machine controls conveniently located for operator?
   Are they easy to use? Are they safe? Can they be made automatic?
5. Must operator continue holding controls after machine starts
   for safety's sake or merely because controls are made that way?
6. Is material received and disposed of in suitable containers?
   Delivered to point of use? Any unnecessary handling?
7. Are tools and materials prepositioned in proper sequence for use?
8. Is it necessary to clamp part? If so, are clamps quick-acting?
9. Is it easy to locate parts in fixture?
10. Can automatic feed be used?
11. Is disposal automatic?
12. Are tools and fixtures the best that can be designed for the job?
13. Can combination tools be used?
14. Are proper gages quickly available? Easy to use?
15. Can parts be made in multiple? One at a time? With another part?
16. Is work place satisfactorily illuminated? Heated? Ventilated?
17. Is work place properly laid out?

OPERATOR

1. Can he perform his work either sitting or standing?
2. Does he do unnecessary positioning? Holding? Reaching? Bending? Turning? Walking?
3. Is he properly performing the job? Would further instructions help?
4. Will it help to change to a taller operator? A shorter one? A more dextrous one?
5. Is material handling by operator reduced to a minimum?
6. Are both hands productively occupied?
7. Is the work balanced between the two hands?
8. Can work now being done by the hands be relieved by foot devices? Automatic
   devices? Holding jigs? Indexing fixtures?
9. Are operators on similar jobs using the same methods?

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Fig. 9.5. A Check List for Use in Process Planning

the product. The extent to which these functions are completely differentiated and grouped in separate departments will depend on the size of the company, as noted above.

The Manufacturing Methods Division

The executive in charge of the process design function has a great responsibility. Customer satisfaction depends largely on the attributes of the product. These attributes are specified initially by the product design organization. They are built into the product by the line organization of the manufacturing division. Manufacturing conditions and methods that are used to create these attributes in the product are specified initially by

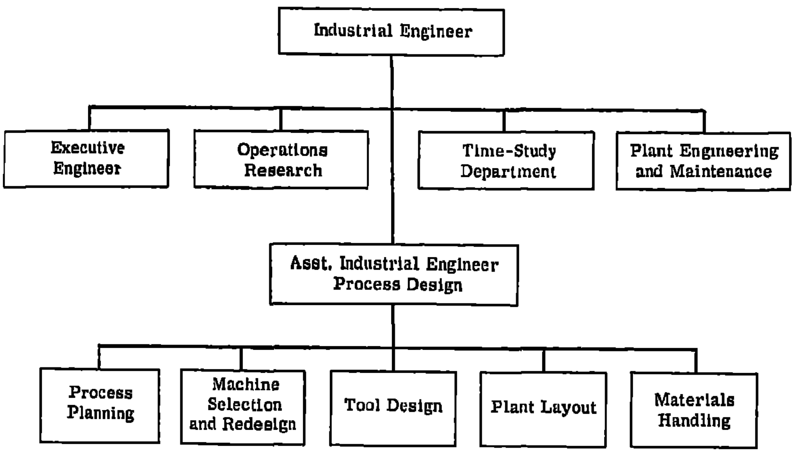

Fig. 9.6. A Process Engineering Organization

a process design organization. Good process design makes it possible to meet the quality standards for the product. It enables us to produce the required quantities of a product at a cost that will leave a reasonable profit. The price from which we subtract this cost must be competitive, of course. A process design department aids the line organization in accomplishing these objectives. It is or should be regarded as a primary technical staff group. It should be attached directly to the manufacturing line organization accordingly.

The title of this executive is different in different concerns. We have used the title of director of manufacturing methods, in Fig. 6.1, to designate the executive who performs the headquarters functions of process planning. It is found frequently, and is descriptive of the field that is covered. The title of industrial engineer has been used to designate the correspond-

ing executive at the plant level. The titles are interchangeable, however. Other titles are used, such as master mechanic, manufacturing engineer, or process engineer. The responsible executive, by whatever title, should have extensive practical experience, as well as professional training in the design of manufacturing methods in the particular industry.

The functions of product and process design may be under a single technical executive in a process type of industry, such as the manufacture of chemicals. The relations between these functions is even closer than in an industry that manufactures an assembled product.

Process Design Organization

The basis of functional similarity within the industrial engineer's organization is the background, training, and experience required to plan, develop, and install manufacturing methods. The need in large plants for technical specialization in the design of manufacturing methods is indicated by the work-simplification check list that is shown in Fig. 9.5. The principal chain of command runs from the industrial engineer, in Fig. 9.6, through the assistant industrial engineer, to the heads of the principal process design groups. The work of these groups has to do with such functions as process layout, machine selection, tool design, plant layout, materials handling methods, and similar functions that enter directly into the planning of manufacturing methods. Such functions as operations research, motion-and-time study, plant engineering, and plant maintenance do not primarily. These functions make some important contributions to economical, effective manufacturing, independently, in addition to supporting the process planning functions. The principal industrial engineering functions will be discussed in the following chapters dealing with manufacturing methods. Their general nature will merely be indicated at this point.

Process Planning

A procedure or method is a related series of complementary functions. Each step in the procedure must produce certain values that will combine with the values created by the following steps to produce the desired end result. This result, in the case of a manufacturing procedure, is a part, subassembly, or finished product that will have the required quality attributes, as specified by the product designer. The process designer has a technical staff responsibility for the determination of what work must be done to make the part or product. This work may be any manual or

mechanical functions that are necessary for the creation of the specified quality attributes. The process designer must break down this work into steps, on the basis of such considerations as the skills, knowledges, and experience required, the equipment and other facilities that must be used, the location of these facilities, the correct order of performance to get the desired end results with the least cost, and others. He determines the "operation layout," in other words, subject to approval by his engineering superior and line concurrence. Almost any home repair job furnishes a simple illustration. It is necessary to replace a floor board, for example. The home owner performs a product design function when he decides that he must use a piece of hardwood flooring of a certain length. He performs a process design function when he decides that he must lay out and mark the required length on the piece, saw to length, fit, and plane to width if necessary, and perform subsequent operations. It is not necessary for the home owner to record his decisions. It is necessary for the process designer, however. He must record his decisions on an "operation layout sheet" or "master plan of work," such as is shown in Fig. 9.7. His decisions are more complex, and must be executed by others.

The decision as to what operations shall be performed on a part or assembly requires a further decision as to how they shall be performed. It will be necessary to select the proper machine for each operation that is to be performed mechanically. A standard machine tool may be quite satisfactory in most cases. It may be possible to get higher quality or lower costs by designing and developing a special machine for a certain operation. It may be better, under some conditions, to modify an older machine that we own. This phase of process planning requires a knowledge of machine design, as well as practical production experience.

A new term, "automation," has come into the language of the production executive and the industrial engineer in recent years. It refers to the automatic handling and processing of materials and product. It represents a continuation of the trend toward an increasing mechanization of work. The public has become aware of a trend toward the "automatic factory," as a result of popular magazine articles. There are some completely automatic production lines in a few large manufacturing plants. The operation and control of processes in many chemical plants are highly automatic, and have been for years. The trend is highly significant. We shall discuss it briefly in the chapter on plant and equipment. We shall merely note here that the development of automation in an industry requires an engineering training for process planning.

MASTER PLAN OF WORK AND SCHEDULE

Date______ Order No.______

Part name______ Part No. ______

Standard ordering quantity______

Models using	A	K		
No. per model	5	5		

Material name______ Usage______ Mat'l symbol______

Op. No.	Operation name	Dept. No.	Machines		Tooling	Men		Unit time		Progress		Schedule	
			No. req.	Mch. class		No. req.	Job class	S U	MT	M	O	Start	Finish
1	Mill Base	12	1	27	Fixture #1874 Std. 3" Milling Cutter	1	21	20'	0 236'				
2	Drill	8	1	31	Drill Jig #1267 Std. 0.5" Twist Drill	1	18		0.143'				
3	Slot												
4	Profile												
8	Inspect												

Fig. 9.7. An Operation Layout Sheet

Tool Design

In some industries, such as clothing manufacturing, in which most of the primary operative functions are power sewing machine operations, tools may be a minor factor in production; but in metalworking industries they are extremely important. Large concerns in such industries usually have a tool design department which designs the jigs and fixtures for holding work in the proper relation to the tool, gauges for determining the degree of quality, and the tools and auxiliary attachments that are necessary to equip machines properly for specific operations. All these will be designated simply tools. Tool design determines the attributes of devices which extend the functions of the machine and adapts them economically and effectively to the requirements of particular operations. If a cutting tool is not designed properly, for example, it may become dull sooner than it should. The machine must then be shut down, the dull tool taken out and sent to a tool-grinding center, a sharp tool set in, and the machine readjusted until the work conforms to the quality required. Poor tool design may increase costs by making it difficult to maintain the maximum rate of production. It may also directly affect the maintenance of quality standards. It is evident that tool design is a phase of the creative planning of process. It cannot be performed until product design, process layout, and machine selection have been completed for the particular part or assembly. A good tool designer requires a specialized training and experience. Blueprints and specifications of the product and a copy of the master plan of work, as it has been developed thus far, are turned over to the head of the tool design department, who assigns the job to a particular tool designer. But what happens in the small plant that cannot afford a tool design department? This work is done by the line executives on the basis of their practical experience. They may have the assistance of a tool designer attached to the superintendent's office. These executives probably can get the help of the executives of some local jobbing tool and die shop that builds the company's tools. In a large concern, when the tools for an operation have been designed, blueprints and the proper orders are sent to the toolroom, which builds these tools to the designer's specifications. The toolroom is a service shop, and is frequently under the production division. The finished tools may be sent directly to the production department that is to use them; but in a large organization it is more likely that they will be sent to some central tool storage crib to be held until requisitioned by the department.

Plant Layout and Materials Handling

Plant layout is the function of determining the physical relationships between the operations that must be performed on parts and assemblies, and such physical performance factors as plant, equipment, storage areas, materials handling equipment, and other facilities. The industrial engineer must know what operations and equipment are required for what products before he can decide where the machines should be set up in which shop departments. Plant layout usually depends on operation layout and machine selection, and follows after these functions. Good plant layout increases turnover of work in process, reduces manufacturing lead time, lowers materials handling costs, and contributes other values.

Materials handling is concerned with the internal movement of materials and work in process. It is an important cost factor in production. Plant layout and materials will be taken up in later chapters.

The Time-Study Department

Operative production standards are measures of economy and effectiveness in the performance of operative functions. These standards provide the line organization with standards of conditions under which a given operation should be done, standards of procedure for the correct performance of the operation, and standards of performance by which to gauge the results in so far as a proper rate of production is concerned. Operative standards should not in any way break down the quality standards for the particular operation. Production standards must be fair to the workman as well as to the company.

In laying out the operations on the metal plate that was shown in Fig. 1.2, provision was made for drilling the hole. The time-study department will study and analyze this operation, at the machine if necessary, to determine what elementary or suboperations must be performed. For example, after the earlier machining operations have been completed, these plates may be delivered to the proper drill press in trays. The first elementary operation may be: "Pick up piece and place in drill jig." The time-study analyst will also study such factors in work as lighting, and the equipment for storing and handling work at the machine. The result of all this investigation and analysis should be the best practicable method of getting the most results under the best working conditions that can be maintained. It is apparent that the motion and time study of operative functions is an extension of operation layout into the operation itself.

Production standards are directly affected by tool design, plant layout, and materials handling. There should be close coöperation between time study and the groups that perform these functions. There are some basic functional similarities between motion and time study and these functions. The time-study department accordingly should be a member of the industrial engineering division of the plant organization. It is sometimes assigned to the personnel division, production control, or the comptroller's division, nevertheless. The reason given may be that time study affects their work or supplies information that they need. It is a misassignment of the function when this happens, in the opinion of this writer. The applicable rule in such cases is well established: functions should be related by procedure, rather than by organization structure, when they are complementary but dissimilar to one another. Such misassignments are less common today, because the nature and contributions of the process planning functions are better understood. They will be discussed further in a later chapter on motion and time study.

Miscellaneous Standards

Many concerns purchase all their standard tools. Drills, for example, have been well standardized as to size, style, and design. Certain twist drill manufacturers have special equipment and a volume of production that enable them to manufacture these tools more cheaply than most concerns could make them for themselves. However, different makes of drills vary as to length of life and efficiency under different conditions. One concern conducted exhaustive tests of different makes of drills to determine their relative economy for specific operations on specific parts. In the course of the year a concern may purchase many thousands of dollars' worth of expense materials. These are materials that are necessary for manufacturing but do not enter directly into production. They should be standardized for economy in use. Purchase specifications should be set up for them.

It is evident that there is a function, in the manufacturing organization, of determining miscellaneous standards. They are called "small" standards in some concerns. These include all standards except those having to do directly with product, process, and direct materials for production. The problem of "small" standards may be assigned to the industrial engineering department, because many of the standards are directly associated with primary operations. This function of standardization may be assigned to engineering research, because industrial engineering probably will have

no testing or research facilities of its own. The function is not shown in Fig. 9.6 for this reason.

The determination of physical standards affects production, purchasing, and accounting, as well as engineering. We therefore may have a standards committee for the plant or company. Its purpose is to coördinate the interests and thinking of these groups. The director of supply, in Fig. 6.1, may well be the committee chairman. The classified list of standard materials, supplies, and parts affects the size of inventories. The value of this inventory in a manufacturing company may run into many millions of dollars. Any miscelleaneous standards that may be developed should be submitted to this committee for its concurrence.

Plant Engineering and Maintenance

The plant engineering and maintenance department is a technical staff organization. It renders a specialized service of facilitation chiefly to the line organization of the manufacturing division. Its head may be known as the maintenance superintendent, or the plant engineer. Its objectives are the provision and maintenance of certain production factors, principally plant, equipment, and power, in a condition that will make possible continuous economical manufacturing. The principal phases of the department's work are frequently plant maintenance, plant engineering, and power production. These functions may be differentiated completely from one another in a large company. They are represented by separate departments in such case. The maintenance department inspects equipment regularly to prevent its breakdown, makes emergency and other repairs on it, takes care of whatever building services may be assigned to it, such as window washing, janitor service, elevator service, etc. It makes the required changes in the locations of departments and machines, when new models of product are to be put into production. These changes must be made in accordance with the blueprints of our plant layout section.

Plant engineering maintains liaison with outside engineering and construction companies when major plant expansions are made. It may make minor modifications of or additions to existing buildings with its own construction forces.

Large plants may find it economical to produce their own power. The company's power plant may operate under the direction of a superintendent. His function is associated closely with building service. It is placed under plant engineering for this reason.

We have placed the plant engineering and maintenance functions in the industrial engineer's organization, because they are associated closely with process planning. It reports directly to the head of the factory organization in some concerns, however.

Operations Research

"Operations research" is another term that is relatively new in management literature. It has been defined as "a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control."[5] The scientific method has been defined previously as any method that applies a logic of effective thinking, based on an applicable science, to the solution of a particular set of problems. There is nothing new in an attempt to apply the scientific method to the solution of management problems.

The term "operations," as it is used here, has a broader meaning than when used in time study or plant layout to designate the steps in the production of a part, or some other operative project. It refers usually to a series of related activities in a major undertaking. Operations research, in this sense, came into prominence during World War II. It was used by the U.S. Navy to determine the most effective depth-setting of anti-submarine depth charges. It was used to determine the optimum number of ships in a convoy, and for solving similar problems.

The current literature of operations research does not show any fundamental differences between it and prewar attempts to apply the scientific method to the solution of management problems. The principal features of operations research appear to be these: It is concerned more with the use of products, facilities, and conditions than with these factors themselves. It makes use of the recorded results of laboratory research, or the results of previous operations over a period of time. It may observe and record operations for subsequent analysis, however. Operations research makes use of a team approach whenever practicable. The team may consist of a small group of individuals who work together for the solution of the assigned problem. Each individual has a good professional knowledge and training in an applicable field of science, but does not have necessarily

[5] Phillip M. Morse, and George E. Kimball, *Methods of Operations Research*, John Wiley & Sons, Inc., 1951, and the Technology Press, Massachusetts Institute of Technology, p. 1. Arthur D. Little, Inc., says that operations research is "the organized application of the methods of scientific research to operating problems outside of the conventional fields of science." *Operations Research*, p. 4 (a privately published pamphlet).

any practical experience with the problem. It is expected that his point of view concerning the problem will be detached and objective. The methods of operations research make extensive use of statistical techniques and the theory of probability. They attempt to develop mathematical statements that express the relationships between the factors, forces, and effects in an operational problem. These mathematical expressions are helpful in solving fundamental and continuing problems. Their usefulness is limited by the presence, in most business situations, of many intangible factors that cannot be quantified accurately. Operations research can recommend a basis for a final decision, accordingly, but it cannot recommend such a decision.

A leading authority on this subject feels that probably "operations research should not be classed as a branch of engineering" because it is concerned with the use of equipment rather than its construction.[6] The operations research unit has been placed in the industrial engineering division, in Fig. 9.6, nevertheless. The methods of operations research are based largely on the approaches of the exact sciences. These approaches are more likely to be fruitful, at this level, when applied to line production operations. The operations research function on the corporate level, in Fig. 6.1, would be located probably in the office of the director of manufacturing methods. It is quite possible, however, to place this function in the office of the vice-president for administrative staff services, but under some other name. This function is in the process of development. Its significance cannot be evaluated yet. The ultimate development and location of operations research in the organization will be decided in the future. It will be a highly significant development undoubtedly.

Process Research

Laboratory research in the field of manufacturing methods, leading to the development of better process, machines, and tools, is as important as product research. Most concerns cannot afford separate facilities for a manufacturing methods laboratory, however. It is therefore probable that such research work will be carried on by the engineering research laboratories for the industrial engineering division.

The Executive Engineer for Industrial Engineering

The executive engineer performs a staff control function in the industrial engineering division. The objectives and characteristics of his function are similar to those of the executive engineer in the product engineering

[6] *Ibid.*, p. 1.

division. He assists the industrial engineer in coördinating the activities of the division.

The Administrative Planning and Control of Design

We have surveyed briefly several fields of activity that have to do with the creative planning of product or process. These functions are present in some form in any industry, but they may differ in their characteristics and development, depending on the nature of the industry and the particular organization problem.

Economy and effectiveness in manufacturing depend largely on the plans that are formulated by the product and process engineering divisions. The reader has undoubtedly realized that the work of these two groups affects that of the sales division, the comptroller, the treasurer, and the general purchasing agent, as well as the production manager. The engineering divisions are technical staff organizations. While they have certain responsibilities and authority for the development of certain plans, they seldom have the right of final decision, or the authority to force their plans on coördinate line and staff organizations. This they do not want as a rule because the responsibility for final results goes with the right of final decision. They are not in a position to accept such responsibility. There is also the danger that they might lose the much-needed coöperation of these other groups. It is the responsibility of the administrative executive to make certain that the organizational interests of all the groups under his direction are adequately considered and serviced. He must see that their activities are properly coördinated with regard to the achievement of the common objectives of all the groups. It is therefore evident that we cannot pass on to other problems without giving brief consideration to the administrative planning and control of design.

We shall base our discussion on a procedure for introducing a new model of an assembled mechanical product. In general, the principles involved will apply to either engineering or nonengineering industries. The details of the procedure will of course be different in every concern. There is a general method of approach, however. It may be broken down into certain rather definite phases. In the author's opinion, these phases are:

1. The inception of design
2. The establishment of the basis of control
3. The preliminary design of the product
4. Experimental testing of this design
5. The final design and the release of engineering information

6. Process design and the release of process information
7. Cost control of design
8. Pilot Plant operation
9. Organization for manufacture of the new product

Research is not a phase of product and process design. In the beginning, no one can tell what the results of a research project will be or when they will be available. These results cannot enter into design until the research department has put the basic data in usable form, and perhaps built a model showing how the fundamental principles operate. There is usually considerable difference between a laboratory model and the commercially salable product.

The inception of design, in a large organization, may begin with the approval of the manufacturing division's plans by the company's executive committee. This committee integrates the thinking of our major administrative executives. It probably includes the men who report directly to the executive vice-president in Fig. 6.1. Further approval by the board of directors or its executive committee may be required, particularly with regard to financing, general policy, and long-range planning.

The coördination of new product design and manufacture should take place at the plant level, when operating responsibility is decentralized to the plant by product lines, on a profit-center basis. The internal coördination and control of design work is the responsibility of the chief of the engineering division of the plant. He is assisted by his executive engineers, as noted previously. The latter release product and process information to the cost department, purchasing department, personnel department and other technical staff groups. This should be accomplished in Fig. 6.1, through the central plant staff services group. This group supplies a staff service for coördinating thought and action at the top echelons of the plant organization.

Before the detailed designing can be begun, it is necessary to know the price class or classes in which the proposed product is to be sold. Effective competition is measured by the company's ability to supply the public with maximum quality at minimum cost in the particular price class. Volume is a factor in costs and profits. Substantial evidence, that the new product will be able to earn the required minimum return on total assets, probably will be required for top management approval. It must be shown that the new product can establish a satisfactory competitive position within a reasonable period of time. If the concern elects to merchandise the new model in a low price class, it may be able to estimate on the basis of a large volume of sales, a small unit margin of profit, and a high turn-

over. In a high price class, the reverse may be true. In the end, the plant executive committee may recommend to the plant manager that the new model should cost not more than, say, $10.00 to make. To this must be added the necessary percentages for general business expense, selling expense, and profit, to determine the selling price. The sales division should know this price before it spends any large sums for advertising and sales promotion, because price is usually an important factor in the public's decision to buy. For example, if it is not stated in advance, the potential customer is likely to decide what price he will be willing to pay; if the price announced later is higher than the customer anticipated, much of the advertising appropriation may be wasted because the customer must make a new decision to buy.[7] It is evident that the permitted cost to make influences the quality of the product, and therfore its design. The sales division's representatives on the product committee probably have ideas on style and service that they would like to have adopted. It is evident that product design is influenced by many nonengineering considerations. These decisions must be communicated to the headquarters offices affected, through the general manager.

In many industries, seasonal buying habits affect the time of introducing new models. New designs of men's straw hats are not brought out in December, for example. In the case of any product that is to be distributed to the general public, the announced date of showing the new model is important. It is the marketing division's task to develop public interest in it to the point where there will be an active demand of satisfactory proportions on or about the time when it is first displayed. If for some reason the company is unable to stock dealers adequately until some time after this date, the public is likely to buy a competing product rather than wait. In effect, the concern has spent some of its sales and advertising appropriation to increase its competitor's business. A year or more may be needed before product design, process design, plant layout, organization changes, and preliminary manufacturing result in the production of the new model in the required volume. Hence it is evident that considerable administrative control is needed to assure proper coördination between marketing, engineering, production, and finance. This is difficult because in its initial stages the work is largely mental. To achieve this coördination central plant control must establish deadlines. This is done largely on the basis of practical experience with the time normally required for each phase of design, organization, and production. Central control must also set up a

[7] At the present time we may be told only how much down and how much per week must be paid.

progress control of such planning for the plant manager.

In the product engineering division the chief engineer and his assistants must also establish deadlines. First, the correct order of design must be decided as definitely as possible. No one designing an automobile would start with the top and work down through the various component parts to the tires. With most mechanisms, the designer must start with the central moving parts and work out. If the concern has been in business for some time, the general order of design has probably been established by long practical experience, unless the forthcoming model is entirely new. Knowing this order of design, the chief engineer can estimate man hours of engineering design work that will be required. He may need more engineers, draftsmen, or other personnel. He can set the approximate dates when the designs of certain base parts and subassemblies must be completed by the design groups to which they have been assigned. It is impossible to fix the number of designs to be completed per day, or anything else like this, because design involves creative planning, which is mental work. As the deadlines approach, some members of the various design groups may have to work overtime; but this is to be expected, for if the engineering department is late in completing its work, the subsequent phases of manufacturing the new model may also be late. In addition, final decisions must be made as to what parts can be carried over from the old model, what ones must be redesigned, what new parts must be designed, what parts shall be purchased, etc. Some of these decisions probably will require conferences with the production, process planning, purchasing, and other organization groups. The engineering department usually has various forms for recording and authorizing these decisions, in so far as they are internal. The executive engineer must keep various engineering records while the preliminary design is being made. He must see that other departments are coördinated, when their work is affected by engineering decisions.

As the preliminary designs are completed, they are released by the executive engineer to the experimental engineering section, where experimental models of parts and subassemblies are built. This section may be a part of the engineering research laboratory. The experimental models should be tested under conditions approximating the extremes of use that the customer will give them. A record is kept of their performance. If they fail to give the proper service, the causes are analyzed to determine whether or not the customer will get the service that he has a right to expect. In the past, manufacturing concerns often carried on their experimental work at the public's expense. For example, their designers would

work out new designs that were apparently all right. After testing a small number of completed products, these manufacturers would produce and distribute them. When too many complaints of a given kind were received the designs would be changed to eliminate the fault. Such practices build up a strong resistance to new models, which hampers the efforts of sales divisions.

During the course of the experimental testing, there are frequent conferences between the designers and the experimental engineers to determine the significance of results. When the tests are completed, the designers alter the preliminary designs to conform with the test findings. After tracings have been made by the drafting room and all the engineering records are completed, blueprints, specifications, bills of materials, and other engineering information are released through the executive engineer by means of engineering release notices that require his signature and that of the design engineer responsible. This information is needed by the purchasing department for estimates of material requirements, contracts, etc.; by the cost department for cost estimates; by the industrial engineer's division for process planning; and by the production division for control purposes.

The use of this information in process planning has been noted previously. The industrial engineer's division records its process information on "process layout sheets" or "master plans of work" similar to that shown in Fig. 9.7. Copies are made for each part and subassembly, and sent to the cost and production control departments, and possibly to the engineering department for its files.

The cost department should play an important part in the control of design. The selling price is usually predetermined on the basis of conditions of supply, demand, and competition, as well as the estimated cost to make. This estimate has been accepted by the responsible engineering and production executives as reasonable. The cost of materials for a part can be estimated on the basis of bills of materials from engineering, estimated purchase costs from purchasing, estimated scrap allowances from production control, and similar information. The master plan of work shows the operation list for the part, the type of machine, the estimated rate of production, etc. The production division can tell what class of labor will be used, and the personnel department can estimate the average hourly rate that must be paid. Thus there is a basis for an estimate of the prime cost of the part. A percentage for factory overhead and administrative expenses must be added to get the estimated cost-to-make. As the plans for the various parts and assemblies are released, first by the engi-

neering and then by the industrial engineer's divisions, the cost of the finished product is gradually built up. If the engineering divisions have completed about 25 percent of the work of product design and have spent about 40 percent of the estimated cost to make, obviously they must call a halt and reëxamine their plans. It may be possible to simplify the design of certain parts, or to use a less expensive material. Perhaps the industrial engineers can simplify or eliminate certain operations on certain parts, or find other ways to reduce the cost of manufacture. What will happen if this is not done? In many modern concerns, the cost department, under the plant accountant in Fig. 6.1, will make its final report to the executive committee. The latter will note that the selling price of, say, $15.00, was based on an original allowed cost to make of $10.00, whereas the final estimated cost is $11.80. Inasmuch as the price of the product cannot be raised without danger of serious marketing difficulties, and in most cases the profit margin will not permit the concern to absorb the difference, the committee will probably tell the heads of the production, process design, and product design groups to cut out the excess cost of $1.80. Hence these groups must reëxamine their plans anyhow. In addition, they may have serious trouble because they will still be expected to meet the agreed deadlines, or target dates for design, production, and marketing.

Pilot Plant Production

There is a stage of pilot plant production in many large companies. A pilot plant is one in which we manufacture a modified or new product on a small scale, but under simulated production conditions. It gives us a chance to try out our tooling, and check its ability to meet quantity and quality standards on each operation on each part. It provides an opportunity to check the accuracy of production standards that have been estimated by the time-study department. Potential bottlenecks in the proposed plant layout may become evident. The pilot plant reduces other organizing costs by uncovering serious production difficulties before the production plant goes into large-scale production. It is evident that these checks have to do largely with manufacturing conditions and methods. Pilot plant operations have much the same relation to process design that experimental engineering has to product design. The executive in charge of such operations may be attached directly to the manufacturing line organization, however. The reason is that pilot plant operations are more closely associated with the function of organizing than they are with planning for the manufacture of new products or models.

Eventually the concern will have purchased such new equipment as

may be required, and any needed changes in plant layout and organization structure will have been made. The purchasing department will have got in the initial inventory of purchased parts and materials, and other problems that may cause the company trouble will have been solved. Finally it will go into production, and if the management's work has been well done, the dealer will get his stock of the new models when they were promised.

Some time has been devoted to product and process planning because these functions are vitally important in manufacturing operations. Furthermore, a study of this work adds to one's understanding of the fundamentals of planning that were discussed earlier. It may give some idea also as to why a large corporation finds it necessary to spend many millions of dollars in planning and organizing, before it ships a dollar's worth of new product.

PROBLEMS

1. Following the close of World War II, automobile firms generally used prewar tooling to supply the market demand for automobiles. About four years later one of the producers introduced a different design in its several lines. The objective was an automobile with significant improvements such as a lower body style with increased head room and greater width for the interior. The engineering of its product had always been excellent. The company was proud of the fact. It had followed the policy over the years of emphasizing the engineering aspects of its product. The newer style did not bring a significant increase in demand. Over the next several years, the percentage of the total market which the firm had held actually declined to a point where it operated at a loss. Only the initiation of a new design which was somewhat similar to those produced by its competitors regained for the firm its earlier position in the market and permitted it to operate at a profit.
   (a) What could be some of the causes of such a development?
   (b) Which function or functions probably were not performed properly?
   (c) What principles and procedures of product planning should have been applied by the company during the years when the above occurrences took place?
2. A manufacturer of office equipment came out with an important improvement in his product. His sales jumped immediately. Within a short time, he was sued by his largest competitor, who claimed that it had developed, several years previously, a device that was functionally identical with the new improvement. While it had not patented the device or used it in its product, it claimed that certain of its common-law rights had been violated, and asked the court to assess damages. It also demanded an accounting of the manufacturer's past sales of the product using this device, for the purpose of determining royalty payments to be made. However, the competitor lost its case because it could not produce the original engineering drawings and

records for its device. Today, this company's engineering department has a modern steel vault and an excellent engineering record system; some people have said that it cost this company approximately $2 million to discover that such things as original drawings and records are of major importance.

(a) What function of the competitor's engineering department was insufficiently developed? How would you classify it?

(b) What principles of procedure may have been ignored in handling original records?

3. A large parts supplier to the automobile industry attributed its success to its flexibility in supplying the auto industry with items which the supplier could produce more economically than could individual auto makers themselves. Such position, the management felt, could be made possible only by having an engineering department which was sensitive to the particular needs of the customer firms. It began to lose sales volume, as a result of cancellations, when a considerable number of orders were delayed in production because of tooling difficulties. A liaison man was provided in an attempt to coördinate relations between the manufacturing engineering department and the production divisions.

(a) Are the difficulties here of an organizational or of a procedural nature, or both? Explain.

(b) What provision should be made for elimination and prevention of such problems?

(c) Where would you place the liaison man in this organization? Why?

4. A firm engaged in the manufacture of heavy machinery has developed successfully a production control system for engineering design work in its product design department. A purchase contract from a vendee company may call for the delivery of only one or two pieces of equipment on or before an agreed date. A single piece of machinery may sell for many millions of dollars. The design of the piece is made to the customer's specification. Few standard parts, if any, can be used. A delay in the work of engineering design, consequently, can result in a serious delay in the manufacture, testing, and shipment of the machine. A delay in shipment can cause great loss to the customer. The purchase contracts frequently carry a penalty clause for failure to ship as promised, for this reason. Such clauses assess damages against the vendor, at an agreed rate, for failure to meet the contract completion dates.

(a) Is it practical to control the production of plans? Can you set production standards for creative thinking, leading to the solution of a problem?

(b) The system of engineering production control is still operating in the above case. In general, what are the principal considerations that would guide you in developing such a system? What would be your general method of applying them?

(c) Is it or is it not possible to set up a control of staff planning in any technical staff department? Why?

5. The New-Way Products Company has developed a new product for which

the sales department has estimated a monthly demand of 8000 units for approximately the next 2 years. The firm is considering two alternative processes. The first, requiring utilization of skilled labor, would involve equipment and tool costs of $2000, with a cost of $200 to prepare, or set up, for a production run. Labor costs and overhead charges would add up to $4.00 per unit. The other process would involve special-purpose equipment costing $100,000, with a setup cost of $900, and combined labor and overhead charges of $2.50 per unit. Material costs under each process would be $.50 per unit. A production run would be made once every two months.

(a) On the basis of the above data, which process would you decide to adopt?

CHAPTER 10 •

• The Plant and Its Equipment

The Importance of the Plant and Its Equipment

MOST successful concerns find themselves forced, sooner or later, to build new plants or make additions to existing ones. The growth in their volume of business may make it necessary for them to provide additional manufacturing floor space. The need for decentralization increases with the size of the concern and the complexity of its functionalization. For example, the volume of production of a new product may be small when it is first introduced. Existing plant facilities may be ample to handle this product along with other production requirements. However, the scope and quality of the service rendered by the new product may be increased greatly by effective research and design. The cost of manufacturing may be reduced through constant study of the problem. Price reductions and intelligent advertising may greatly increase the demand for the product. Hence within a few years it may be economical and necessary to differentiate completely its manufacture, and to set up a division for it that is largely autonomous. In such a case, new plant and manufacturing facilities will probably be needed. The various factors in plant location may make it desirable to locate the new plant at some distance from the parent plant. If so, the necessity for decentralization is still greater. The usual effect of this is to make necessary certain office, service, and other plant facilities that might not be needed to the same extent if all the manufacturing activities and their control could be centralized. It is expected, of course, that economies in other directions will compensate for any increased charges for additional facilities. In some instances, other factors and forces may create plant problems. For example, a shift in the location of markets or the development of new sales territories for the company's products may make it necessary to establish branch production or assembly plants, branch warehouses, etc.

The successful concern is constantly expanding its service objectives.

Plant and equipment are obviously items of productive capital. Problems of plant and equipment tend accordingly to be recurrent. The solution of these problems usually involves considerable investment. Mistakes are not corrected easily. The head of an organization cannot abdicate his responsibilities by delegation. For this reason he should have a sound fundamental but general administrative knowledge of certain technical problems. Competent consultants may be employed to design and supervise the construction of a new plant. They must work with the company's line and staff executives so that the plant will meet satisfactorily the concern's manufacturing problems. There are ample opportunities for errors of judgment.

There has been a steady increase, since World War II, in the hourly rates for factory operatives. This has been accompanied by increasing taxes. Customer resistance to price increases has become stronger, as wartime shortages have been eliminated and competition has increased. It has become imperative to reduce costs and increase capital turnover in many industries. One method of accomplishing these objectives is by the mechanization of work. The productivity of capital is increased as a result of the transfer of skill and knowledge from the man to the machine. The general effect on the relative productivity of management, capital, and labor is shown in Table 1.

The country's plant and equipment have become a military and a political factor, as well as an economic factor, to a greater degree since World War II. The industrial potential of a country is a major factor in its ability to wage war successfully. We have presently a greater industrial potential than any country with which we may become involved militarily. National security requires that this advantage be maintained. This means that the nation's plant and equipment must be kept modern, as well as adequate for civilian and military needs. Keynsian economics has emphasized the importance of capital investments as an "economic multiplier." It is obvious that capital expenditures for new plant and equipment tend to generate purchasing power and employment. This effect extends far beyond the value of the original construction and purchase contracts. Our political leaders have been committed to an economic policy of full employment. They have recognized the force of capital investment in maintaining or increasing the general level of business. Accelerated amortization, artificially cheap money rates, implied threats of government competition, incentive taxation, private operation of government-financed facilities, and other means, have been used to stimulate capital investment by private industry. There is the obvious danger that a given company or industry

Table 1. Index Numbers of Productivity and Unit Labor Costs in Manufacturing (1947-1949 = 100)

	(1) Production	(2) Productivity of Management and Capital	(3) Labor Productivity	(4) Average Hourly Wages	(5) Unit Labor Costs
1946	90	91	99	82	90
1947	100	95	105	93	98
1948	103	100	103	102	102
1949	97	105	92	105	100
1950	113	112	101	110	99
1951	121	112	108	120	107
1952	125	116	108	126	108
1953	136	121	112	133	110

Note: Column (2)=(1)/(3), or in other words,
(Total Productivity)=(Labor Productivity) × (Productivity of Capital and Management)

Column (3) is expressed in terms of man hours worked, on the assumption that increases in labor productivity that result from increased labor skill and know-how, are due largely to training by management. Good morale is largely a result of good leadership. Low morale can offset superior equipment, however.

Column (5)-[(3) × (4)] ÷ (1), or in other words,

$$\text{(Unit Labor Costs)} = \frac{\text{(Man-Hours Worked)} \times \text{(Average Hourly Wages)}}{\text{(Production)}}$$

Sources: Federal Reserve Board; Department of Labor. All calculations are by the Department of Economic Research, Prentice-Hall, Inc. The index numbers have been rounded off to the nearest whole number, obviously. The figures are seasonally adjusted. The captions for Columns (2) and (3), and the statement of assumptions underlying Columns (2), (3), and (5) and those of this author.

may overexpand its plant capacity at the wrong time in the business cycle. Such a condition may act as a cyclical depressant, rather than a stimulant.

The executive leadership of a manufacturing concern must be able to forecast the normal growth of its civilian business. This leadership must develop long-range plans for the expansion of its facilities, as well as its organization.[1] The management of a company cannot determine intelligently the extent to which it can coöperate with governmental agencies in plant expansion, unless it has developed such long-range plans. We shall take up further the problem of long-range facilities planning, when we look briefly at industrial accounting and finance.

Objectives in Building or Modernizing the Plant

A modern plant contributes certain basic values to a manufacturing situation. They enable a manufacturing organization to do a more com-

[1] It is not necessary to make long-range financial commitments, of course, except for scarce natural resources. New plants can be constructed within 60 to 90 days, with modern high-speed construction methods.

petitive job of serving its customers, at a profit. These values are the principal objectives of a program for building or modernizing a plant. They are secondary objectives of the manufacturing organization, since they do not serve directly the needs or desires of the customer. The principal values that are contributed by a modern plant have to do with: (1) greater manufacturing economy and effectiveness, (2) a faster rate of turnover of working capital, and (3) better organizational morale.

Greater manufacturing economy and effectiveness may include a number of important subvalues. Some of them are (a) the facilitation of manufacturing processes, (b) good working conditions, and (c) reduced operating costs. Dean Kimball used a continuous-process stamp mill as an interesting example of the relation between manufacturing processes and the type and design of the building.[2] This plant was built on the side of a hill in order that the force of gravity could be used to carry ore through processes. Many other illustrations could be offered to show that the facilitation of manufacturing processes is an important consideration in plant design. In fact, many of the following examples may be regarded as special cases under this general principle.

Good working conditions are good business. These conditions contribute to the development of operating economy and effectiveness, as well as to good morale. For example, the modern trend in design is toward the concealment of electric and compressed-air power lines in the floors, columns, or other structural elements. There is less interference with illumination; orderliness and neatness of appearance are enhanced; good plant housekeeping is made easier; other desirable values are acquired. But some flexibility in the arrangement of the outlets for these power lines is necessary, because the arrangement of machinery and equipment tends to change with changes in product or process. Access to power lines for maintenance purposes must also be considered.

When certain processes require the use of complex, delicately adjusted machinery, excessive vibration may lower the rate of production seriously and result in too high a percentage of scrap and seconds. It is obvious that production is interrupted whenever it is necessary to check the adjustment of a machine. Therefore modern plants using heavy machinery set such equipment on separate foundations. They can be insulated from the adjacent floor slabs, in concrete buildings, by the use of semiplastic materials. These materials absorb vibration rather than transmit it. Light machinery also may be insulated against the transmission of vibration to

[2] Dexter S. Kimball, *Principles of Industrial Organization*, McGraw-Hill Book Co., Inc., New York, 1933, p. 78.

and through the building. In some cases, the various sections of a building have been insulated to reduce vibration through its frame.

Good illumination and good ventilation are important physical factors in performance. They may affect also the design of the building. The quality and intensity of illumination directly affect the quality and quantity of production. Good lighting is a factor in the reduction of accidents. A well-lighted work area is more pleasant to work in, and one in which a person can work more effectively. In so far as natural illumination is concerned, the trend in design is, and has been, to put as much of the side walls in glass as possible. This trend has had a distinct effect on the architecture of the factory building. The use of sawtooth and other monitor types of construction is also common. The problem of natural lighting affects building design in other ways. Artificial illumination does not usually influence the characteristics of the building to the same extent.

Air conditioning, although not a new problem, has made rapid strides in recent years. The control of air conditions is necessary for the efficient manufacture of certain types of product, such as food products, textiles, etc., for variations in temperature or humidity may be reflected directly in variations in the quality of such products. Air conditioning is often introduced to provide better working conditions for the operative employees. There has been a marked increase in its use in the South. The usual result is a marked increase in *per capita* production, as well as better employee morale. The effectiveness of air conditioning is determined greatly by the characteristics of the building. If the roof and side walls are not insulated properly against heat loss, if air leaks badly through window sashes, if the windows are open most of the time, and if in other respects air conditions cannot be controlled properly, no air conditioning equipment can function with any high degree of effectiveness. In recent years, a few concerns have built their plants without windows and have installed air conditioning, believing that they could thus supply better and more uniform illumination artificially, maintain much better air conditions, and in other ways create more satisfactory working conditions.

Tool-grinding centers and substorerooms have certain service functions for production, and may require special facilities that must be considered in designing the building. Even the location of washrooms and toilet facilities may appreciably affect the economy of production.[3] In con-

[3] Moritz Kahn has used an example of a factory building 600 feet long by 300 feet wide, housing 500 employees. His estimates indicate that the time lost in walking will be approximately 50 hours per employee per year, if the toilet facilities are concentrated in one room; only 12.5 hours if they are located in two rooms at the

sequence, such facilities may be regarded as service centers for production, as well as for the employees.

Another important consideration in plant building is the reduction of building service and maintenance charges. These charges are often a considerable item in operating costs. They tend to increase as a building grows older. They may be a significant factor, consequently, in the decision to build or modernize the plant. A few examples will show the relation of building design to plant maintenance. Since sharp corners are natural dirt catchers, the junctions of interior surfaces in modern buildings frequently are rounded. The charges for maintaining floor surfaces vary considerably with different flooring materials and different manufacturing conditions. Wood flooring is not suited to processes using large quantities of water if the floors are damp or wet much of the time. Concrete tends to "dust" under heavy trucking. In consequence, changes in manufacturing processes and conditions may make it necessary to change the floor surfaces in certain areas. Modern single-story buildings eliminate the necessity for elevators, and the expense of operating and maintaining them. Some buildings have monorail tracks around the top of the exterior wall surfaces. Scaffolds suspended from trolleys greatly facilitate the work of window cleaning.

Concerns that are developing new products or improving existing ones find it necessary to change the layout of their machinery and equipment periodically. Large companies engaged in straight-line production and continuous assembly of standard products usually have to make extensive changes in layout every year. The cost of these changes may run into hundreds of thousands of dollars. It is evident that the arrangement of equipment must greatly affect the economy of manufacturing. A detailed discussion of this point will be given later; here, however, certain manufacturing economies that are related to the characteristics of the plant building should be noted.

A problem that must usually be considered in building a plant or changing its layout is the handling of materials. In some concerns, 60 percent or more of the time that work is in process is nonproductive, or dead time. The latter is time during which the work is moving between operations, waiting at a machine for the next operation, moving to or waiting for inspection, moving between departments, etc. Much of this dead time may

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quarter points in the length of the building. (See "What Type of Plant to Build" in *Factory Management and Maintenance*, April 1937.) Assuming an average hourly rate of $2.00 per hour in 1955, the cost of travel time for the 500 employees would be $50,000.00 per year. This is the cost of 25,000 man hours of lost time. Only 6250 man-hours, worth $12,500.00 would be lost with two wash rooms.

be unnecessary. How much depends on several factors, such as plant layout, production control, etc. An important factor, as a rule, is materials-handling equipment, such as cranes, conveyors, battery trucks, etc. An intelligent use of this equipment together with good internal transportation speeds up the movement of work and increases the turnover of work in process. It may aid materially in the control of production. It reduces the labor and cost of handling materials, and makes other important contributions to economy in manufacturing. If certain types of equipment, such as traveling cranes, will be needed, their requirements should be considered before the building is designed. Some modern multistory buildings have ramps to facilitate the movement of battery trucks and truck trains between floors. If automatic elevators and spiral gravity-roll conveyors are to be used to move materials between floors, this should be taken into account. It is evident that the requirements of efficient materials-handling equipment affect building design. Conversely, the characteristics of the factory building affect a concern's ability to use this equipment efficiently.

The maintenance of economical relationships between the various physical factors in performance depends in large part on the ease and economy of plant expansion. As we have seen, these relationships are affected by the extent to which floor areas are well integrated and logically related. If economy in production is to be maintained, new manufacturing areas must be integrated with and related logically to the existing floor space. The ease and economy with which this may be done varies with the type of factory building. The amount invested in land and building, and tax and insurance rates, are also affected by the type and construction of the building. These will be discussed later.

There are basically two ways in which the rate of profit on assets can be increased: One is by increasing the rate of turnover of assets. The other is by increasing the profit margin on sales. There are many ways in which we can increase the rate of turnover of assets. The provision of modern plant buildings is one of them. One objective in plant layout, for example, is an economical physical relationship between equipment and other facilities. The intent is to reduce to a minimum the distance through which work in process has to move between operations. An effort is made to eliminate, as much as possible, the backtracking or crisscrossing of work on its way toward the finished goods storeroom, the assembly floor, or the shipping dock. This tends to reduce congestion, speed up the movement of work in process, reduce the investment in work in process as a result of higher turnover, etc. A concern's ability to approximate a straight-

line layout of equipment depends on the flexibility of the floor space. The more it is integrated in larger rectangular areas free from columns or other obstacles, the easier it is to meet this requirement. Some factories are merely aggregations of buildings of various types, sizes, and vintages, that have been erected when and as the need for additional floor space has been felt; there may be no logical relationship between the various buildings, and the floor space may be cut up badly. Under such conditions, it may be impossible to achieve the most efficient equipment layout. It has been noted previously that ability to make effective use of materials-handling equipment depends partly on the characteristics of the building. Such use also speeds up the movement of work, and contributes other benefits that will be noted later. It may be possible to minimize the required investment in land and construction, by a judicious selection of the kind and type of plant building. Supervision is a line phase of control. It is facilitated by open, unobstructed factory areas. Staff production control is facilitated by good plant layout. All these developments tend to increase the rate of turnover of capital assets. They are affected directly by the characteristics of plant.

Organizational morale is a resultant of the mental condition of individuals and groups within the organization. It is reflected in their attitudes toward the company and its leadership, including their immediate superiors. Evidences of it may be seen in their willingness or unwillingness to work diligently, coöperate with their associates, exercise initiative within the limits of policy and method, and in other ways. Good organizational morale is usually a requisite for maximum results with minimum costs. Good leadership is the principal factor in its development. Good working conditions are also an important factor. A great deal of thought is being given to the reduction of noise and vibration within the plant. Noise is a definite factor in fatigue. One may become accustomed to it, but it has its effect nevertheless. Because a quiet plant is a more pleasant place in which to work, the reduction of noise tends to improve organizational morale. In this, as in most management problems, the service objectives of the management and the organization are closely identified with the personal objectives of the employees. Acoustic blocks, plaster, and other sound-reducing materials are being used increasingly in the interior surfaces of factory buildings. Floor materials also have a bearing on employee fatigue, for the person who has stood or walked on concrete all day is more likely to be tired than one who works on wood, wood blocks, or some resilient composition flooring.

We have noted a number of instances in which employee comfort and

Fig. 10.1. Style Research Buildings and Auditorium at General Motors Technical Center. (Courtesy, The General Motors Corp.)

safety have been important considerations in building design. Such cases are, of course, examples of intelligent selfishness on the part of the management, because high morale and high *per capita* production, maintained continuously, tend to go together. A related consideration is the appearance of the plant. An attractive, well-designed plant promotes community good will. It contributes to the elimination of factory districts, which are usually eyesores. It also has an influence on employee morale. Such a plant suggests a progressive, successful organization and may therefore stimulate pride in the company. As Fig. 10.1 shows, the trend in design is to achieve a pleasing appearance by well-proportioned but simple geometric masses which have strong, flowing lines rather than ornate architectural embellishments. The effect is frequently reinforced by appropriate landscaping.

In the course of this discussion, we have noted a number of factors that affect the ability to achieve certain objectives in constructing a new plant or modernizing an old one. The more important are: (1) the character-

istics of the product, (2) the characteristics and requirements of manufacturing processes, (3) the volume of production and its secular trend, (4) the general type of manufacturing activity—continuous or intermittent, (5) the characteristics and requirements of materials-handling equipment, (6) the effects of manufacturing activities and environment on the employees, (7) the requirements of good plant layout, (8) land values and other factors in plant location, and (9) the characteristics of various types of building structure and construction.

Types of Industrial Buildings

The more common types of industrial plants can be grouped into four classes: (1) single-story buildings with either a flat or a sawtooth roof, (2) monitor types, (3) multistory buildings, and (4) special types.

Single-Story Buildings. The single-story building has a number of advantages. When it is equipped with a sawtooth roof, as shown in Figs. 10.1 and 10.2, the natural illumination in the shop is excellent. Almost any

Fig. 10.2. Single-Story Sawtooth Construction. (Courtesy, Albert Kahn, Inc.)

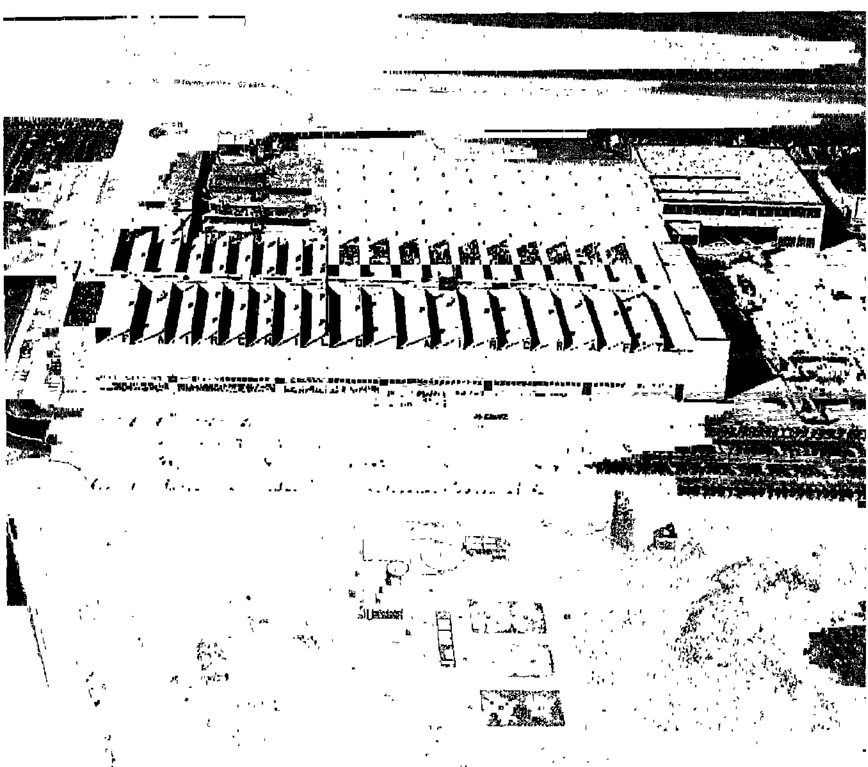


Fig. 10.3. Monitor Construction at the New Departure Division of General Motors. (Courtesy, Albert Kahn, Inc.)

desired width of building is possible. The building can be expanded easily as more space becomes necessary. With special truss construction, there can be 100-foot spans between columns, and as a result, the manufacturing space is broken up as little as possible. The comparatively unobstructed view of operations is often an aid in controlling them. Unobstructed space permits greater flexibility in the arrangement of equipment. Heavy machinery can be placed on foundations set directly into the ground, thereby reducing the amount of vibration throughout the building. Little nonproductive space is required for elevator shafts, stairways, and other service features that are necessary in the multistory building. The cost of moving materials is usually less because the distances are shorter; furthermore, no materials-handling equipment is necessary for moving them between floors. Sawtooth construction or skylights give good natural ventilation. These and other advantages make the single-story type of building, when properly designed, very desirable for many kinds of manufacturing. Its chief disadvantage is the high cost of land and con-

struction per square foot of manufacturing space; scarce and expensive land may prohibit this type of plant.

Variants of sawtooth construction are single-sawtooth, double-sawtooth, and high-and-low-bay construction. There is a trend toward level-roof construction, with a minimum of window space, however, when factory work areas are air-conditioned and constant artificial illumination is supplied.

Monitor Types. The roof truss, Fig. 10.3, is surmounted by a monitor. Such buildings may be constructed with steel frames, with or without con-

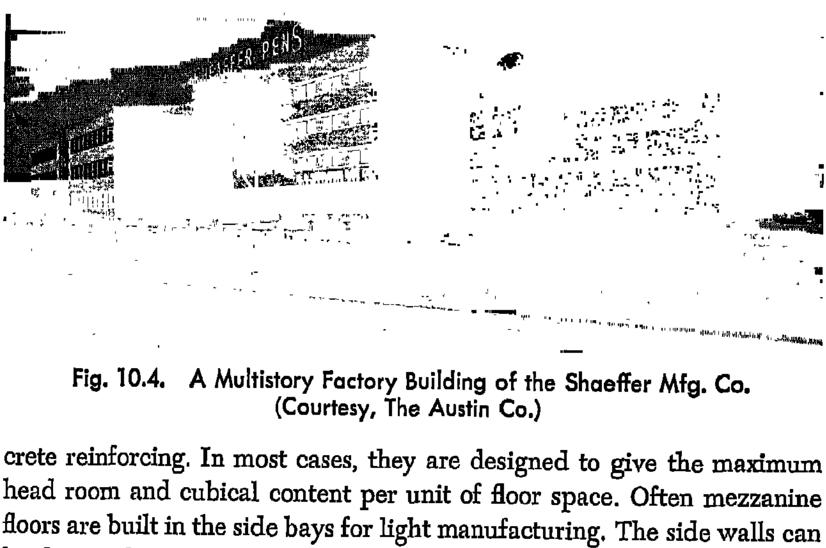


Fig. 10.4. A Multistory Factory Building of the Shaeffer Mfg. Co. (Courtesy, The Austin Co.)

crete reinforcing. In most cases, they are designed to give the maximum head room and cubical content per unit of floor space. Often mezzanine floors are built in the side bays for light manufacturing. The side walls can be designed so that almost 100 percent of the effective lighting area is in glass. The monitor gives good natural ventilation. The monitor type of building is frequently used for heavy manufacturing or assembly operations requiring crane service and considerable head room, or for housing processes such as foundries and heat-treating shops, which, in addition to requiring crane service, give off considerable heat and gases.

Multistory Buildings. The chief advantage of a multistory building, such as the one shown in Fig. 10.4, is that it gives the maximum square footage of manufacturing floor space per square foot of ground space. For

this reason, this type of building may be desirable when land values are high. It is well adapted to light manufacturing. In the case of an assembled product, the operations on the different parts can be laid out so that all work moves in the same general direction to the assembly floor, with minimum movement between floors. If the material is not bulky or heavy, and proper materials-handling equipment is provided, the cost of moving raw and worked materials will not be excessive. If the process calls for pumping liquids, blowing light loose bulk materials, or handling liquid, bulk, or pacakaged materials by gravity flow, the multistory building may offer an economic advantage in materials handling.

On the other hand, it has a number of disadvantages. Under many manufacturing conditions, the problem of moving materials is more complicated than in the single-story building. Time is spent by individuals and materials in moving between floors. Dead space for elevators, stairways, and fire escapes must be provided. Head room and floor loads are limited, unless special construction is used; this is usually expensive. The width of the building is limited. If a building is more than 50 or 70 feet wide, the natural illumination in the center of the shop is likely to be poor, despite the fact that ceiling heights are greater.

Under most conditions, the 4-story standard factory building has the lowest cost per square foot of floor space. Above 4 stories, the cost of construction increases rapidly, for better foundations, heavier steel work, thicker walls, more elevators, and generally more expensive construction must be used. For most manufacturing purposes, either the single-story or the monitor type is far better than the multistory building, provided financial considerations do not require the latter. They are almost always used for continuous manufacturing in large volume.

Special Types. In many cases, the buildings of a plant are combinations of the above three general types. In other cases, however, the building is especially constructed to accommodate the needs of the particular business. Such buildings may be classed as special types. Their disadvantage is their lack of flexibility—any extensive change in the character of the processes tends to make them obsolete.

Types of Factory Construction

The more common types of factory construction can be grouped in five classes: (1) wood-frame construction, (2) brick construction, (3) slow-burning mill construction, (4) steel-frame construction, and (5) reinforced concrete, including "daylight" construction.

Wood-Frame Construction. Wood-frame buildings can be erected

quickly and cheaply, and alterations can be made cheaply. However, this type of construction depreciates rapidly and insurance costs are high because of the fire hazard. It is seldom used for other than temporary buildings.

Brick Construction. Brick construction is more permanent than wood-frame construction, and depreciation charges are less. The side walls and fire walls are brick. The beams are carried on the side walls, necessitating relatively thick pilasters; this reduces the amount of wall space that can be put in glass. Alterations and extensions of the plant can be made with relative ease. With ordinary brick construction, the fire hazard is considerable and insurance rates are high. This type of construction is not generally used for modern plants.

Slow-Burning Construction. One form of brick-and-wood construction that has been used widely in the past is the slow-burning type. The theory underlying this type is that, if the construction is heavy enough to prevent it from gaining headway easily, a fire can be localized for a considerable time. There is an opportunity to get it under control before it assumes serious proportions. Slow-burning mill construction is still the cheapest in some sections of the country. It has been largely superseded, however, by steel-frame and reinforced-concrete buildings.

Steel-Frame Construction. Steel-frame construction involves the use of steel columns, beams, girders, and roof trusses. The outside and fire walls usually are brick curtain walls erected between the columns. In some cases, the side walls are constructed of corrugated sheet steel. Such buildings are hard to heat. They are suitable only for housing processes which give off considerable heat. All steel work should be fireproofed with concrete or some other suitable substance to prevent it from twisting and warping during a fire. Steel-frame construction has the advantage of low first cost. The larger construction companies which specialize in industrial buildings have standard designs for steel-frame construction that can be erected quickly. Alterations and extensions are relatively easy to make. On the other hand, depreciation is more rapid and the fire hazard is usually greater than in the case of reinforced concrete buildings.

Reinforced Concrete Construction. In the buildings shown in Figs. 10.4 and 10.5, the steel framing is incased in reinforced concrete. Floors frequently are constructed of reinforced concrete slabs supported directly on the columns or on girders between the columns, with beams between the girders. Wood floors are often laid over the concrete so that machinery may be anchored easily, the noise of transportation equipment reduced, etc. Plain concrete floors make it expensive to change the location of

machinery. The ceilings are concrete surfaces. Special provision must be made accordingly, for mounting overhead conveyors, power-transmission equipment, and other ceiling installations. Provision for plant expansion should be made in advance of construction as far as possible. Otherwise it may be necessary later to remove considerable reinforced concrete around columns and girders—a difficult and expensive procedure.

The above disadvantages of reinforced concrete construction are considerably outweighed by its advantages. Such construction depreciates more slowly than any of the preceding types. The fire hazard is less. Charges for depreciation and insurance are low as a result. Because of its great durability and the greater ease with which it can be kept clean and sanitary, maintenance charges are low. Such buildings can be insulated against vibration, reducing it to a minimum.

Daylight Construction. As the accompanying illustrations show, the modern trend in design is toward the greater use of daylight construction. Not only does this make possible better natural illumination, but it permits greater building width in multistory buildings.[4] In this type of construction, the side walls carry none of the floor load. Instead, a row of columns runs the length of the building about 6 feet from these walls,

[4] To secure good natural illumination, ceiling heights must have the proper relation to building widths. Ceiling heights vary from 12 to 18 feet, with building widths from 60 to 80 feet approximately.

Fig. 10.5. Reinforced Concrete Construction in the Plant of the Singer Mfg. Co. (Courtesy, The Austin Co.)

the floor slab between the columns and the side walls being treated as a cantilever in designing the building. Inasmuch as the side walls are not required to carry any of the floor load, almost 100 percent of the effective wall area can be glass.

The design details of new plant and its construction will be decided initially by the plant engineer, and probably with the advice and assistance of a firm of industrial architects and engineers. These decisions usually will be subject to approval by a higher line executive, as in the case of any major staff decision. This higher executive will look at the problem from the viewpoint of administrative management. He will want to know how proposed plant additions and expansions fit into our long-range plans for the growth of the business. He will be interested in the financial obligations that may be incurred as a result of the proposal. He will be interested in the turnover of investment that probably will be obtained. He will want to know probably the effect of investment in plant on our fixed charges and break-even point. He will leave the operating and engineering details to line and staff subordinates. The line subordinates in the manufacturing division are interested chiefly in the effects of proposed plant designs on the economy of operations. It is the problem of the plant engineer to convince our line operative executives that the proposed designs will do what they want done. These operative executives usually have a good practical knowledge of the relation of plant to manufacturing operations. They may not be engineers, however.

Process Design

The characteristics of an existing plant affect usually the characteristics of our manufacturing processes. The reason is that we cannot modify the existing plant sufficiently to meet process requirements completely. The ideal approach is to design the product, and then the processes by which it is made. The most effective and economical relationships between the principal steps or operations in these processes can be worked out. A layout plan, showing the locations of machines and departments, can be made. The plant building is then designed around this layout. This is the approach that may be used when we are building a branch plant in a new location, and a standard design of factory building cannot be used.

The nature of process design was discussed generally in Chapters 6 and 9. It was defined as the function of planning the physical conditions and methods used in producing a product, and the relationships that should exist between them. The objectives of process design are manufacturing methods that will enable us to produce the required quantities of the product, with the specified quality, at a competitive cost, or better. Any

major planning problem begins with a determination of the primary service objectives of the organization, the values with which it must serve the customer. These values are indicated specifically by forecasts of probable monthly sales by product and price lines. They are indicated also by product specifications received from engineering. The order that authorizes the work of process design usually indicates the maximum daily or monthly production of each product for which we shall tool up. This maximum may be some percentage of forecast peak sales, say 80 percent, depending on the company's ability to regularize production and employment. The staff objectives of the process design group are secondary, of course: The customer does not buy manufacturing methods; he buys manufactured product.

The principal phases of process planning were shown in Fig. 9.6. They are operation layout, machine selection, routing, tool design, plant layout, and materials handling. These functions were shown under the direction of an assistant chief industrial engineer. His chief reported directly to the plant manager. The corresponding function at the headquarters level, in Fig. 6.1, was headed by a director of manufacturing methods. It was pointed out that there is no standard terminology for this field at present.[5] One very large manufacturing company, for example, has four executives who handle different phases of the manufacturing methods function: a plant engineer, a manufacturing engineer, a tool engineer, and an industrial engineer. Each executive reports directly to the plant manager. The industrial engineer, in this instance, is responsible only for time-study and production standards.

The same engineering order that authorizes product design may authorize the design of the methods by which the product is made. A request for authority to design may be made by the product design department. This request may go initially to a product committee, composed of representatives of sales, finance, production, product engineering, manufacturing methods, purchasing, and top management. This committee may recommend the request, with appropriate modifications, when a meeting of minds has been accomplished concerning design objectives, policies, costs, and similar factors. The general engineering design order, that authorizes design, should be issued through the office of the general executive in charge of production. This would be the vice-president in charge of manufacturing in Fig. 6.1. Copies of this order would go to the

[5] The Society for Advancement of Management has published a *Glossary of Terms Used in Methods, Time-Study and Wage Incentives*. This is the best effort to standardize terminology in this area that has been made to date.

director of manufacturing methods and the industrial engineer of the plant where the new product is to be processed.

The product information concerning a part or assembly is received from product engineering, when the design is released by the executive engineer in charge of it. The information consists chiefly of blueprints and specifications stating the required dimensional and other characteristics of the particular part or assembly. The use of the information is authorized by an engineering *release notice* that accompanies it. The first step in process design, after the receipt of the necessary business and engineering information, is operation layout. This is the function of determining the steps or operations that are required to make the item in accordance with its specifications, and the order in which these operations should be performed. We saw, in Fig. 1.2, a metal plate in which a hole had to be drilled in a specified location. The job of drilling this hole is an operation, or step, in the processing procedure for making the plate; the end result of the procedure is a part that will meet the dimensional and other specifications of the product engineer who designed it. Before this hole can be drilled, certain operations must be performed—the first may be to mill the bottom surface of the plate; the second, to mill one side, etc. It is not necessary for our purposes that we understand the mechanical characteristics and requirements of these operations. It is apparent that the plate must have certain reference surfaces from which the plate can be held in the jig. If these surfaces are not in the right dimensional relation to one another, the hole cannot possibly be drilled in the correct location with reference to them. From this it is evident that certain dimensional values had to be created before the values associated with the drilled hole could be created economically and effectively. The order in which these values are required has established the order in which the various operations must be performed. Thus far, two things must have been determined on the basis of the product designer's specifications: the functional content of the various major steps, or operations, in the procedure for making the part or assembly, and the best order for doing them. These are the principal phases of process layout. The functional content of each operation will vary with the type of manufacturing in which we are engaged, as well as the characteristics and requirements of the product. The method of drilling the hole in the plate shown in Fig 1.2, for example, presupposes a certain condition of the number of pieces required, the standardization of the part, and the quality limits that must be met. A certain method would be used if the plate were nonstandard and we were making 10 pieces only for a special order. Another method would be used if we

were making 1000 per hour steadily to meet the requirements of a continuous assembly line. It would be possible for the plate to have the same design and the same quality requirements in both instances. We would be operating under some condition of intermittent manufacturing in the first case; under some condition of continuous manufacturing in the second. Differences in this condition would be the principal controlling factor in the situation as stated.

The function of routing is associated closely with the function of operation layout. It is that phase of process planning that determines where the operation shall be performed. The routing of a part will be different, again, depending on the type of manufacturing in which we are engaged. It will be seen, when we look at the plant layout function, that this factor governs largely the location of machinery in the plant. It is obvious that a quantity of parts must be moved to the location of a machine that can perform a required operation before it can be processed. We shall assume that the operation layout sheet in Fig. 9.7 is for the fabrication of the plate that we have been discussing. The drilling operation is No. 2 on the operation list. This operation will be performed in Department 8 because there is a drill press there of the right kind and type; the location of the department is the closest to Department 12; the foreman in charge of Department 8 has the knowledge and experience necessary to assure the production of the part to quality specifications, or some similar consideration may govern the decision concerning the routing of an order for the part. It is evident that a decision concerning the machine or machines to be used on each operation must be made before we can lay out the order in which the operations on a part should be performed. The controlling consideration is still the necessity for an economical and effective build-up of values in the part, as processing progresses. This build-up must meet the final quality specifications of the part when it has been completed.

An operation layout sheet or master plan of work, such as the example in Fig. 9.7, may be originated by the manufacturing methods or industrial engineering department. This sheet accumulates the required manufacturing information as it travels from section to section within the department. Some of the information must be obtained from other staff departments usually. The information on the sheet, that is above the operation list, has to do largely with product. This information is obtained from the product engineering department, with the exception of information having to do with a specific order number, and the ordering quantities. The information on the lower part of the sheet is entered by the

industrial engineering department, with the exception of that concerning personnel and schedules. Information concerning job classifications is obtained from the personnel department. The determination of ordering quantities and schedules is not regarded usually as a function of industrial engineering. Fig. 9.7 is intended apparently to be used by the production control department as a progress control record. It may be the practice, in such case, to type the permanent product and process information on an operation layout sheet that has been printed with "ditto" ink. The resulting "ditto master" can be filed for later duplication when we have occasion to run an order for the part. The temporary manufacturing information, having to do with the order number, ordering quantity and schedule will be typed in by the production control department at that time.

Plant Capacity and Machine Selection

The initial decision concerning the machine that is to be used on a given operation on a part is usually a staff decision. The staff department that makes this decision may be the industrial engineering department. This assumes that this department performs all the manufacturing methods and plant engineering functions. The basis of this decision will be the type, kind, size, and number of the particular kind of machine that will enable us to meet the quality specifications for the operation with the least cost. Such decisions must have the concurrence of the line operative executive who is responsible for the proper performance of the operation. The reason is obvious: a line executive cannot be held accountable for the results of staff decisions that have been made without his consent, concerning primary performance factors. Equipment is a major factor in primary operative performance. These decisions must have the approval of a higher line executive when they involve the purchase of a major installation. Such purchases involve major problems of capital provision and application. Top management wants analyses, furthermore, showing the effects of such proposed purchases on break-even points and capital turnover.

The determination of the type and size of equipment that should be used is based on the differences in unit costs for the particular operation, using alternative machines and methods. There are at least 6 different types of machine tools, for example, that could be used to create the hole in the plate in Fig. 1.2. Not all of them will meet the quality, quantity, and time requirements of the problem equally well, however. Those that cannot meet these requirements in the minimum acceptable degree are eliminated immediately. The cost comparison is between those that can

meet them. A simple example will illustrate the problem, in so far as cos is concerned. We shall assume that either of two types machines wil meet the quality requirements of operation No. 22 on part 560. We ar using at present two machines of type A. Their installed cost is $1000.0 each. It has been proposed that we replace them with one improved typ B machine. It is the company's policy that an investment in capital equip ment must pay for itself out of savings, before taxes, in 4 years or les The following is the principal information concerning the proposed pu chase of the installation.

	Type A	*Type B*
N, Annual requirements for Part 560	5000 pcs	5000 pcs
I, Installed cost of machines	$2000.00	$4000.00
P, Estimated rate of production of each machine for the operation	1.3 pcs/hr	2.4 pcs/hr
Standard work year	2000 hr	2000 hr
Operators required per machine	1 man	1 man
Operator's hourly rate of pay	$1.80	$2.00
Power of motor driving the machine	2.5 hp	4.0 hp
Cost of electric power per kwh	$0.05	$0.05
A, Rate of interest on money	6%	6%
B, Allowance for taxes and insurance	4%	4%
C, Allowance for machine repairs and maintenance	6%	6%
D, Depreciation and obsolescence	10%	10%
Burden rate on direct labor	70%	70%
Material cost per piece	$0.50	$0.50
Total operating hours (5000 pc/) (*P*)	3845 hr	2083 hr
Power requirements per hour @ 85% operating efficiency. (1 hp=0.746 kw approx.)	2.194 kw	3.511 kw
Total power required	8435.9 kwh	7314.5 kwh
E, Total cost of power @ $0.05/kwh	$421.80	$365.72
L, Cost of labor, with ave. departmental productive efficiency of 105%, $\frac{\text{(op. hr} \times \text{hrly. rate)}}{1.05}$	$6591.43	$3968.19
O, Overhead expense @ 70% of direct labor	$4614.00	$2777.73
M, Material cost (5000×$0.50/pc.)	$2500.00	$2500.00

	Type A	Type B
X, Percentage of year that one machine is in operation (op. hr)/(2000)	192.3%	1.042%
F, Fixed operating cost of machine, $I(A+B+C+D)X$	\$999.96	\$1083.68
U, Unit cost$=\dfrac{(M+L+O+E+F)}{N}$	\$3.025	\$2.139
S, Percent of annual cost saving $\dfrac{(\$3.025-\$2.139)N}{X\times I}\times 100$		106.3%
Years required to amortize investment out of savings (100%)/(S+D)		0.86 yr or 10 mo approx.

The substantial reduction in unit costs resulting from the purchase of the type B machine may appear to be an exaggeration. It is not, in many cases. In the metalworking industries, for example, metallurgists have improved tool steels and their ability to cut metal. Metal-cutting machines have been redesigned to get the higher production rates that are now possible. The principle of simultation has been applied in connection with the development of automatic machine operation.[6] We have machines that perform simultaneously a number of successive steps on a part. Machine designers are accomplishing an increasing transfer of skill and knowledge from the operator to the machine. This also increases the rate of production and reduces unit costs. The application of these and other design principles are the responsibility of the machine designer. The industrial engineer may be interested in their application when we decide to modify the design of one of our machines to increase its operating economy. The line executive in the manufacturing division is interested chiefly in the cost-reducing possibilities of new or modified equipment. The type B machine, in the above case, will pay for itself in less than a year. This is well within the limit, established by company policy, of 4 years before taxes. This machine would appear to be a good purchase, other things being equal. They may not be equal, however. A decision had to be made initially as whether we should make or buy part 560. There would be no capacity requirement for operation 22, if the part were bought from an outside parts manufacturer.

There are other considerations than quantity and cost that may induce

[6] The principle of simultation merely says that with the simultaneous performance of the steps in the completion of a project, the time required for the project is the time for the longest step.

us to buy a new machine for an operation on a new part or product: It is often the case that a machine can produce a higher quality of work at the same cost. This is an important consideration, obviously, when quality is a major factor in competition. The size and weight of the piece are important factors in the manufacture of producers' goods. The forging in Fig. 10.6, for example, could hardly be made by a village blacksmith.

The company's position in the business cycle is also a factor in the decision to buy or not to buy a major piece of equipment. It is true that

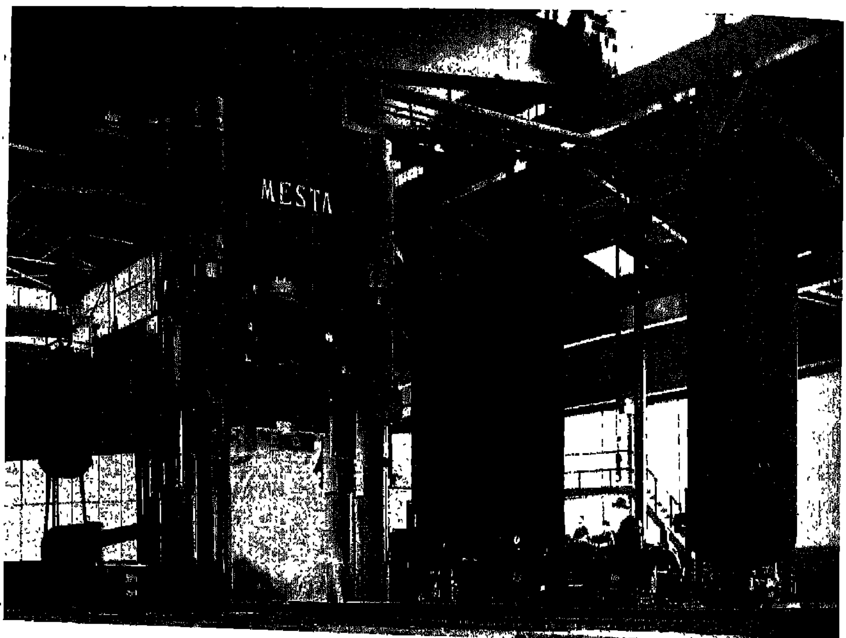


Fig. 10.6. A Heavy Forging Press. (Courtesy, Mesta Machine Co.)

building and equipment plans and programs are derived from long-range forecasts of capacity requirements. These forecasts are based on the long-range trend of sales. The lead time for equipment program planning may be 5 years or more. The lead time for purchase commitments for equipment varies from 6 months to 3 years, depending on the size, complexity, and standardization of the installation. The top management of a company avoids, at the peak of a business cycle, a substantial increase in the company's funded debt, any significant increase in the company's break-even point, and any considerable addition to fixed charges. It is practically impossible, however, to tell exactly when an industry will reach a cyclical peak in its business. It is therefore likely to be the policy that a company

will not commit itself for major equipment purchases any farther in advance than is necessary. It must have reasonable assurance of business volume that will permit a substantial write-off of the equipment, through savings, before any serious business recession develops. We have an interesting case, consequently, in which equipment program planning is based on the secular growth of the business, but equipment purchases are based on intermediate or short-range planning.

Governmental policy may also be a factor in the decision to expand capacity. Changes in the rate of equipment purchases by American industry can stimulate or depress noticeably the general business level. The job of vote-getting is much easier for the political officeholder when the country is prosperous. Since the first duty of a politician is to get himself reëlected, his short-run obligation to keep the country prosperous is obvious. Governmental inducements to maintain equipment purchases may be offered in some form of "incentive taxation," in consequence. The Internal Revenue Act of 1954, for example, allowed a form of accelerated equipment depreciation that is known as the "sum-of-the-digits" method.[7] The proportion of the original cost of the equipment that is amortized under this method when one-half of the depreciation period has passed, is between 70 and 75 percent. It would be only 50 percent at the same point in the period if a straight-line depreciation method were used. The Office of Defense Mobilization ruled in October 1954, that "an extra bonus up to 25 percent (above the amount of rapid amortization) would be allowed as a tax write-off on new facilities of defense and defense-supporting industries in distressed areas."[8] There is nothing wrong with accelerated depreciation. Such depreciation tends to accelerate the mechanization of industry. It reduces the adverse effects of plant expansion with growth on the ability to plow profits into the business and maintain reasonable dividends. A negative form of governmental incentive to expand is the veiled threat by an important governmental agency that it will build certain facilities if private business does not.[9] There is an implication of governmental competition with private enterprise. Such adventures in state capitalism tend to weaken the foundations of private capitalism, on which our economy rests.

[7] The "sum-of-the-digits" method is simpler than its name. Each annual depreciation charge is that fraction of the original installed cost that is represented by the "reverse year" of the machine's life, divided by the sum of the digits or year in its life. The sum of the digits is 55, if the machine is depreciated over a ten-year period. The depreciation charge for the first year would be 10/55 of the original installed cost; for the 10th year, 1/55.

[8] See *Dun's Review and Modern Industry*, November 1954, p. 56.

[9] W. C. Bryant, "Federal Factories," *Wall Street Journal*, June 13, 1952.

It is evident that many decisions of a nonengineering nature enter into the selection and purchase of equipment. These decisions probably will not be made by the industrial engineering department. The bases for some of these nonengineering decisions will be examined briefly in connection with purchasing and finance. The final decision falls in the field of general administrative management, of course.

Automation and Cybernetics

The terms "automation" and "cybernetics" are relatively new in the language of management. The fundamental ideas that they represent are not new. Many of the management and manufacturing techniques associated with them are new, nevertheless. It is almost certain that their use will influence greatly the conduct of American industry. It is therefore necessary that the industrial executive have at least an administrative knowledge of these concepts. An industrial engineer obviously should have technical knowledge.

Automation may be defined as that field of knowledge which deals with the automatic handling and processing of materials. This is a narrow definition. John Diebold feels that it deals with "both automatic operation and the process of making things automatic. In the latter sense it includes several areas of industrial activity such as product and process redesign, the theory of communication and control, and the design of machinery."[10] The latter definition is obviously broader. It suggests that we may be able to develop the automatic performance of both managerial and operative functions, or certain phases of them, when the conditions for economical automation are present. We may have, in other words, some automatic performance of operations, and some automation of certain phases of the work of planning for or controlling these operations.

The objectives of automation are basically the same, regardless of the kind of work that is "automated": A common objective is a reduction in the labor cost of production. Automation requires a transfer of skill, knowledge, and effort from the man to the machine. The rate of production of the machine is very much higher than that of the man, as a result. The employee may get a higher rate of pay, nevertheless, than he received before automation. A completely automatic production line may cost hundreds of thousands of dollars. The employee has acquired an operative responsibility for the use of capital that may represent a small fortune. It is this responsibility that justifies his pay rate. Unit costs may be much lower, on the other hand, because fewer men are needed for the same

[10] John Diebold, *Automation*, D. Van Nostrand Co., 1952, p. ix.

volume of production. Another objective may be the conservation of our skilled or professional man power. We never have enough to go around during periods of rapid expansion. Another objective may be higher capital turnover. Automatic equipment is much more expensive than nonautomatic, but we get a much higher rate of production per square foot of factory floor space. This higher rate also means a shorter lead time of production orders on customer shipping dates. It may be possible, in addition, to produce a more uniform quality of product. Automatic controls of automatic equipment may make possible a closer continuous adjustment to quality requirements than is possible through manual adjustment by a machine operator. These and other objectives account for the widespread interest in automation among manufacturing executives.

The automation of primary operative performance is usually of greatest interest because of the importance of reducing prime costs. An example of such automation is shown in Fig. 10.7. The low ratio of labor to capital is evident. The control stand in the foreground enables the operator to control his production line, or any operation in it. (The problem of automatic control will be discussed shortly, when we look briefly at "cybernetics.") Any such major capital investment must meet the criteria of an economical purchase that have been noted previously. Automation has also entered the field of staff operations. There have been many applications of automatic equipment to office production. A large railroad equipment manufacturer has applied an electronic calculator to the computation of employee retirement records. The machine enables a single operator to do in one week the work that otherwise would take 4 people 3 months to accomplish. If the company paid $250,000 for the machine, which would be a reasonable price for it, the installation would pay for itself out of savings at current average pay rates in less than 2 years. This assumes that the machine can be kept busy at the same rate of savings for 75 percent of its time at least.[11]

The automation of planning, through the use of electronic computers, has been well publicized. It has been applied to problems of research and design for both product and process in connection with highly complex calculations. The objectives in this area have to do chiefly with the conservation of time and the use of scarce scientific and technical abilities. Cost reduction is likely to be a secondary objective. There is no mathematical, mechanical, or electrical substitute for human brains, of course. The giant calculating machines, that have been called "electronic brains," can operate only on a plan and data that have been given to them by

[11] James P. Thurber, Jr., "Electronic Brains," *Wall Street Journal,* July 25, 1953.

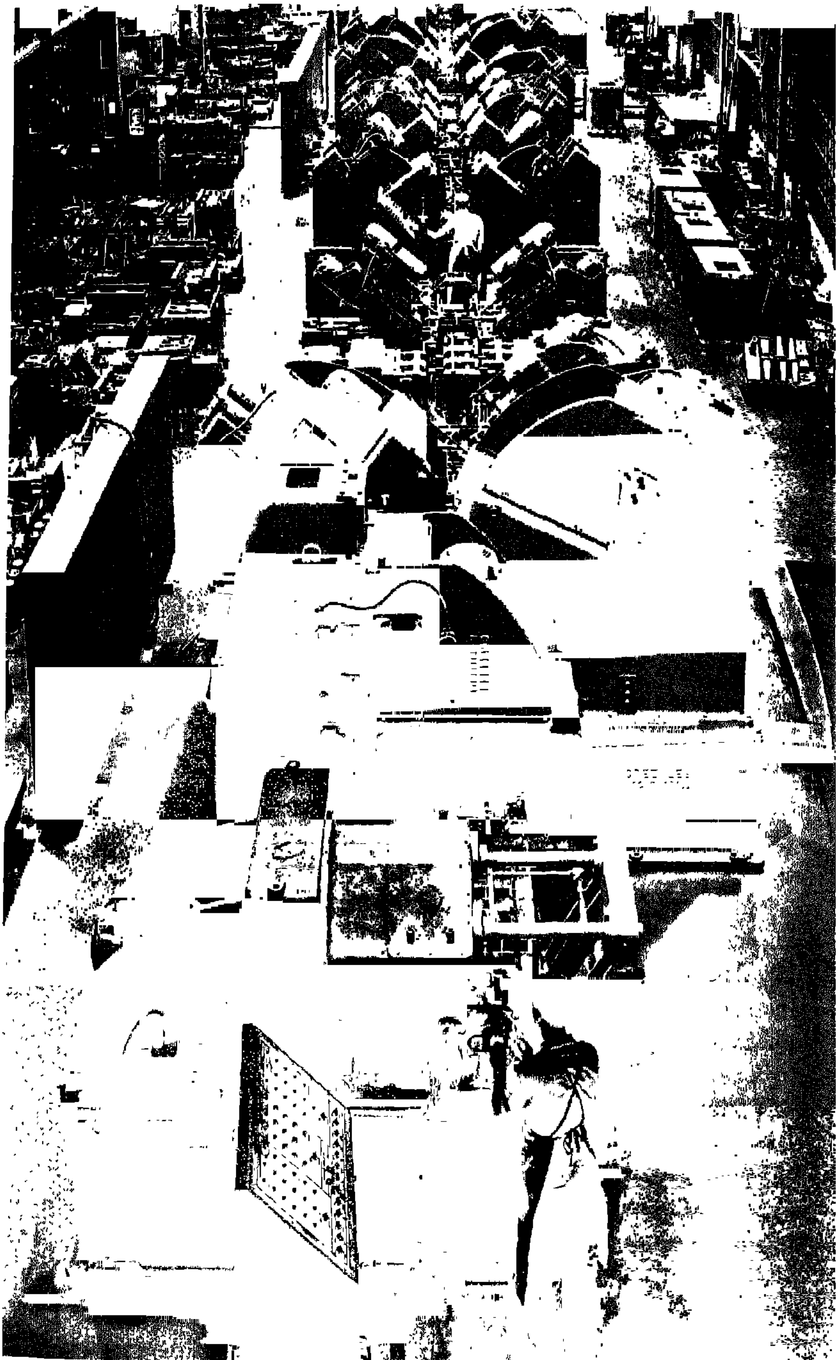


Fig. 10.7. The Cylinder-Head Line, Wright Aeronautical Corporation. (Courtesy, Greenlee Bros. and Co.)

people. They can, however, perform certain routine repetitive mental operations with incredible speed.

Cybernetics has been defined as that field of knowledge which deals with the science of communications for the purposes of control. (There is also a problem of communications for the purposes of planning.) Cybernetics obviously is closely associated with the control of operations. These controls may be manual with nonautomatic performance. They are usually mechanical or electric with automatic operation. The principal phases of the system, in either case, are: (a) The receipt of a signal or communication indicating a significant deviation from standards of correct performance; (b) The evaluation of the signal and the determination of the corrective action that should be taken; (c) The "feedback" of information concerning this corrective action to a device that controls the performance of the operation. This device is an individual, obviously, when performance and its control are manual; (d) The corrective adjustment of the process by the device to restore satisfactory performance. A common example is the thermostat that controls the home heating system. The thermostat is set to hold room temperature at a certain level. A signal is sent to an electric device on the furnace when the temperature drops below this level. This device opens a valve, in the case of a gas furnace, starting a flow of gas to the burners. Corrective action has been started. The thermostat evaluates the rise in temperature that follows. It sends a signal closing the valve when the temperature has risen again to the desired level. Corrective action has been completed. This is known as a "closed loop" system, because the control system is directly associated and integrated with the conditions of performance that must be controlled. An "open loop" system is one in which control is directly associated with performance but it is not integrated with it.[12] Most manual controls are of this nature. The control systems may vary from simple relationships of oral communications and manual adjustments to very complex systems. The latter may rely on electronic signals, electronic computers for interpreting these communications, and electric feedback to various servomechanisms for making the necessary adjustments in process conditions. They are correspondingly expensive.

There is basically nothing new in automation. It is merely a continuation of the trend toward the transfer of work, skill, and intelligence from man to the machine. The movement has been accelerated by the development of various electronic devices. This movement is most evident, at present, in mass production industries. There are current developments, however,

[12] John Diebold, *op. cit.*, pp. 10-20.

that may give the automatic machine greater flexibility. Such machines may be applicable, in such case, to short production runs under conditions of intermittent manufacturing. It is possible, but not probable, that automation will result temporarily in technological unemployment. There is no evidence of it at present. Mechanization tends to spawn small service industries. It should aid the older worker since automation tends to increase the importance of maturity, judgment, and a sense of responsibility. It tends to decrease the importance of manual dexterity and physical strength. The results of automation should be beneficial to the general public, since an increasing standard of living depends on increasing *per capita* production.

Tools and Tool Design

A tool may be defined as any implement or instrument used directly by a man or machine in performing work.[18] The term "tooling" refers to all the various kinds of tools that are necessary for the various operations on a part or product. Tools are important factors in the cost of production. They are expensive to make. A good tool designer may be able to reduce costs and improve quality greatly through good tooling, nevertheless. A large plant engaged in the continuous manufacture of a consumer durable good may spend millions of dollars in tooling up for a new model of product.

The work of tool design includes the planning of such devices as the following:

Tools: The implements that are used directly on material by the man or the machine to perform an operation on the product.

Dies: A kind of tool used by certain types of machines in performing such operations as piercing, stamping, drawing, forming, bending, and extruding. Such operations usually involve an application of force that makes the material take a shape that is determined by the form of the die. (See Figs. 1.1 and 10.6.)

Jigs: Movable devices for holding work in the proper relation to the tool or tools in the machine. (See Fig. 1.2.)

Fixtures: Work-holding devices fixed rigidly to the bed or frame of the machine. (See Fig. 1.1.)

Gauges: Devices for determining the degree of quality that has been produced. (See Fig. 16.12.)

[18] We use frequently the term "machine tools" to designate the machines that apply the tools to materials in performing work. "Hand tools" are implements that are used for the manual performance of work. The term distinguishes them from tools that are used by machines.

Auxiliary Attachments: Devices for adapting the mechanical functions of a machine to the requirements of an operation on the product.

The work of tool design is affected also by the nature of the tooling that is required. This tooling may be temporary or permanent. Temporary tooling is usually quicker and cheaper to make. It may enable us to meet the minimum quality requirements of the product, but unit operation costs may be high. Its chief virtue is that it may enable us to get into production earlier than would otherwise be the case. This advantage may be more than sufficient to offset the disadvantages of higher operating costs when we are at war, or in a condition of hard competition. The latter is particularly true when some competitor has come into the market unexpectedly with a superior product.

Because of the large capital expenditures required to produce any kind of tooling, it is necessary to examine carefully the probable economies resulting from its use. The general method is similar to that used previously in connection with the selection of machines.[14] The following case example is probably oversimplified. It will illustrate satisfactorily the general method of approach, nevertheless.

We shall assume that it is necessary to manufacture a part for an assembled product under conditions of continuous manufacturing. Our estimated requirements for the part during the coming year are 150,000 pieces. It has been recommended that we redesign the fixture that is required for a certain operation on the part. The new design would cost $1500 more to make than the present fixture design. It would enable us to cut our present labor cost for the operation by $0.015 per piece, however. This labor saving has been estimated by our time-study department, using standard operation element times and standard time relationships. The increased cost of the fixture must be written off out of savings within the manufacturing year. This is necessary because we redesign our product models annually. It is estimated also that there will be an additional cost for the repair and maintenance of the fixture, during the year, of $200.00. Other factors in the problem are shown below.

A=Interest charges	6.0%
B=Taxes and insurance	4.0
C=Maintenance charge ($200/$1500) ..	13.3
D=Depreciation and obsolescence	100.0
F=Fixed cost	123.3%
I=Additional cost of the fixture	$1500.00
N=Annual requirement for the part	150,000 pieces
S_o=Cost saving per piece	$0.015 per piece
O=Overhead charge on direct labor ...	70%

[14] The late Professor Joseph W. Roe of New York University developed a number of formulas for computing jig and fixture economies. See Alford and Bangs' *Production Handbook*, Ronald Press Co., 1944, for examples of their application.

S=Savings, shown by the expression

$$[N \cdot S_o\ (1+O)] - I(A+B+C+D) = \$1980.00$$

P=Percent profit on increased cost, or $(\$1980/\$1500) \times 100 = 132\%$

H=Years to write off out of savings

$$= \frac{100}{(P+D)}; \text{ or } 100/232; \text{ or;}$$

$$= 0.43 \text{ year, or } 5.2 \text{ months}$$

The immediate technical staff responsibility for tool design falls usually on a chief tool designer or chief tool engineer. He reports directly to the manufacturing methods manager or chief industrial engineer. The tool engineer plays a very important part in the work of production planning in the modern manufacturing plant.

Plant Layout and Its Objectives

Such factors as the operations that must be performed on a part or product; the order and place of their performance; the machinery, tools, and auxiliary equipment required for each operation; materials-handling equipment; and similar factors, exert a more immediate and direct influence on the economy of manufacturing than does the plant that houses them. Determination of the correct relationships between them is correspondingly important. Each year, American manufacturing concerns spend hundreds of millions of dollars to develop such relationships. Much of this money is spent for what is called "plant layout." It may be defined as the work of planning and organizing the physical conditions and relationships between plant, equipment, and operations that will make possible a satisfactory degree of manufacturing economy and effectiveness.

The principal objectives of good manufacturing management are superior customer service, lower costs, greater effectiveness in the use of capital, and greater organizational effectiveness. Superior customer service is the primary objective of the business organization. The company's competitive position can not be improved unless this objective is accomplished satisfactorily. The company cannot develop the volume of business that is necessary for profitable operations unless it improves its competitive position. The other objectives noted are secondary. Lower costs are necessary for competitive sales prices with satisfactory profit margins. An effective use of capital results in a higher turnover of assets. The latter is necessary for a satisfactory return on invested capital. Higher morale is an important factor in greater organizational effectiveness. The objectives of good plant layout can be classified under the objectives of good management, as stated below:

1. *Superior Customer Service*
   a. Shorter and more reliable order delivery promises
   b. A better quality of product
2. *Lower Production Costs*
   a. Reduced materials handling costs
   b. Less unabsorbed overhead expense
   c. Lower labor costs
   d. Lower cost of scrap and waste
3. *Higher Turnover of Current and Fixed Assets*
   a. A faster flow of work in process
   b. More effective utilization of machine capacity and man power
   c. Higher rate of production per square foot of factory floor space
   d. Higher inventory turnover
4. *Higher Organizational Morale*
   a. Less physical effort required of operative employees
   b. Fewer accidents
   c. Better working conditions for both executive and operative employees
   d. Increased organizational pride

Time and quality are important factors in good customer service. The promised date or rate of delivery of a manufactured article to the customer is often a legal consideration in the purchase contract. A reliable delivery date depends in part on a smooth, uninterrupted movement of work through the plant. The lines of movement are usually studied for each product and part. An effort is made to remove potential points of congestion in the flow of work, eliminate bottlenecks due to unbalanced machine capacity, and shorten the flow lines along which work progresses. Other provisions can be made during plant layout that will accelerate work flow. It may be possible, in a plant that is well laid out, to give the customer satisfactory deliveries without the expense of overtime work, excess productive capacity, or inventories that are unnecessarily large. The quality of a product may be affected substantially by the manner in which it is handled and moved through the operations and processes that enter into its production. Quality, rather than price, may govern competitive effectiveness in some manufacturing fields. Materials handling for quality maintenance is usually studied carefully in connection with plant layout for this reason.

Price is an important consideration in customer service. Profits are necessary for the growth and expansion of the business, as well as for the satisfaction of the collateral objectives of owners. Cost is a factor in both price and profit. The cost of handling and moving materials is an important element in the cost of production. It is reduced by providing

for the use of faster materials-handling equipment of greater capacity, when the plant layout is made. A good plant layout also facilitates the maintenance of a steady, continuous flow of materials and work in process. The amount of machine down time due to internal delivery failures is likely to be less, and in consequence the cost of unabsorbed overhead expense. The labor cost of production is less for the same reason. There is likely to be less scrap and seconds when we have a steady, continuous movement of production that is handled properly. The cost of defective product is an important cost of production in some industries. There are other ways in which a good plant layout can contribute to lower production costs. They have to do with the provision of adequate space for the operation and maintenance of the machine and for the storage of raw and worked materials at the machine.

The rate of return on capital is equal to the rate of capital turnover times the rate of profit on sales. It is evident that the turnover of our current and fixed assets is an important consideration in the management of an industrial enterprise. There are many ways in which good plant layout tends to improve such turnover. A faster flow of work in process increases the turnover of this important item of current assets. Plant layout tries to eliminate bottlenecks in production by balancing production between operations, departments, or classes of equipment within the plant. It does so by providing approximately equal amounts of the various kinds of machine capacity that are needed to meet production requirements. There is less idle equipment for this reason also. The result is a higher rate of turnover of this class of fixed assets. An objective of plant layout is a higher rate of production per square foot of factory floor space. It is accomplished through many of the provisions that have been noted above. This higher rate of production means a higher rate of turnover of our fixed investment in land and buildings. It is usually the case that the layout of our warehouses and storerooms is studied at the same time that we study the layout of directly productive plants. It often happens that the cost of receiving, storing, and disbursing stores is reduced. The speed of handling materials, and in consequence the turnover of inventories in stores, may be increased at the same time.

Organizational morale is not the principal objective of good plant layout in most instances. It may make some important contributions to good morale, nevertheless. Good working conditions are good business. They are a value in which any employee is interested. Their provision through good layout tends to integrate the interests of the company's organization

and its individual employees. In other ways, good plant layout may contribute to good morale.

Factors and Principles in Plant Layout

Anything that affects the proper physical relationship between plant, equipment, men, and machines may be a factor in plant layout. Obviously there may be a great many of them, and they tend to be peculiar to the type and kind of industry; however, some are so basic that they affect most industries. In an assembled product, for example, the principal factors usually are: (1) the volume of work to be handled; (2) manufacturing policy; (3) the products to be manufactured, including their component parts, and subassemblies; (4) the assembly relationships between the component parts and subassemblies of each product; (5) the operations needed on each part, subassembly, and final assembly; (6) the kind, size, and capacity of the machines required for each operation; (7) the conditions necessary for manufacturing processes or operations; (8) the characteristics and locations of the manufacturing areas for each part, subassembly, and final assembly; (9) the characteristics and requirements of auxiliary services necessary for production; and (10) whatever materials-handling equipment may be required.

It is apparent that the volume of work that must be handled in connection with the production of parts, assemblies, and finished goods affects greatly the amount of productive capacity, both man and machine, that is necessary for each operation on them. It affects, in many cases, the type of employee and machine that can be used most economically, as well as the kind and amount of materials-handling equipment. The volume of work determines largely the kind of manufacturing that is most profitable. It may vary in an infinite number of degrees within an industry. Manufacturing activity may vary accordingly. Highly intermittent manufacturing is at one end of the scale. It is a kind of manufacturing in which men and machines are applied to materials for limited periods of time. An operation on a given order may keep a machine busy for a few hours, but at the end of that time it will probably be necessary to change the tools and reset the machine so that it can be used for another order. The so-called "job shop" which does small quantities of work to the customer's order and specifications necessarily engages in this kind of manufacturing. The concern that is engaged in continuous manufacturing is at the other end of the scale. This is a kind of manufacturing in which men and machines are applied to materials for extended periods of time. The large-

scale manufacturing of automobiles, washing machines, television sets, and similar consumer durable items, for example, usually brings out new models annually. The number of changes made in product and process during the manufacturing year is relatively small. The effects are minor. Once an automobile plant sets up a production line for the manufacture of pistons, the machines used on each operation probably will continue to run on that operation during the life of the model. Production is subject to the usual interruptions caused by tool changes, machine breakdowns, employee absenteeism, etc.

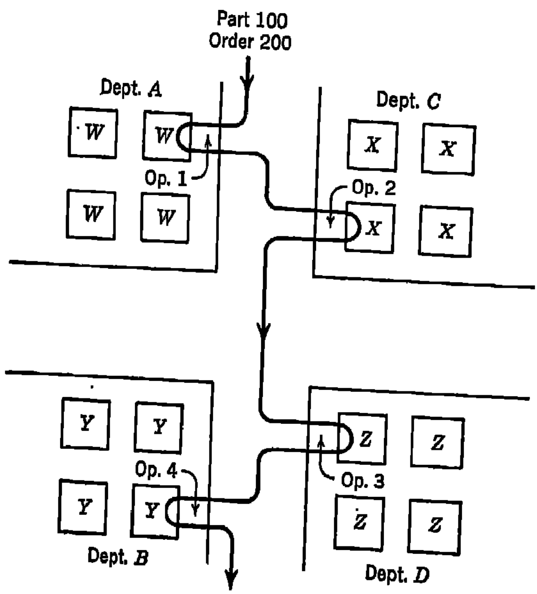


Fig. 10.8. Operative Functionalization Based on Equipment Characteristics

We noted in our discussion of organization fundamentals that the primary line organization develops by devolution from the organic functions of the business, and that its continued devolution tends to result in primary operative specialization. We saw also that, as far as the division of responsibility is concerned, primary operative functions are grouped principally on the following bases: (1) product, commodity, or service; (2) the physical dispersion of operations; (3) process or method; and (4) equipment, or some other dominant physical factor in performance. The manner in which line operative functions are grouped affects the physical layout of the plant, as well as it organization in departments. The small concern that is engaged in intermittent manufacturing, for example,

frequently finds it necessary to group equipment by kind, to gain flexibility in its use. The general nature of such a grouping is shown in Fig. 10.8, where the letters W, X, Y, and Z indicate kinds of equipment. We shall assume that the concern is a small metalworking plant which has a lathe department, a milling machine department, a planer department, etc., with a foreman in charge of each. If these departments are big enough, he may have under his direction an assistant foreman and a shop clerk, in addition to mechanics. Such an arrangement produces a definite type of specialization. Both the foreman of the milling department and the foreman of the lathe department, for example, may have served their time as machinist apprentices. The former probably knows more ways of doing work on milling machines quickly and economically, nevertheless, than does the latter. The foreman of the lathe department probably has a far greater knowledge of lathe work, on the other hand, than the milling foreman.

Larger concerns, engaged in so-called mass production, afford many examples of shop departments set up on the basis of the characteristics of product, rather than equipment.[15] If the volume of work is large enough, the equipment necessary for the manufacture of a given product can be lined up according to the exact sequence of operations called for in its manufacture. The basis of functional similarity, of course, is the common objectives in the manufacture of the product and the similarity of the problems which arise, in so far as they relate to the manufacture of this specific product. There is usually another basis of similarity in that all the equipment, while not of the same kind, is in the same general class, such as light machine tools. The general nature of such a grouping is shown in Fig. 10.9. We shall assume that the same product is being manufactured as in Fig. 10.8 with the same equipment, but on a continuous basis. The foreman of this department may also have served his machinist apprenticeship, but the specialization connected with the manufacture of a specific product produces quite different results. There are always problems which are peculiar to the making of a given product. There may be an excessive amount of tool breakage on certain operations, for example. There may be difficulty on other operations in getting out the required rate of production continuously and at the same time meeting the standard of quality. The foreman in charge of a production line, such as the piston line in a plant making automobile motors on a continuous basis,

[15] We do not imply that only large concerns can engage in continuous manufacturing. The principal requirement is ability to balance capacity economically between operations, and to apply the various factors continuously. Inasmuch as a volume is a factor, the larger concern is usually more able to do this.

becomes a specialist in the manufacture of that particular product. While his fundamental training may be the same as that of the milling machine and lathe foremen referred to above, the foreman of the piston job undoubtedly could get out more pistons of better quality than could either of the other foremen. It is evident that the volume of work is a fundamental factor that affects the type of manufacturing, the division of line responsibility, the selection and grouping of equipment, and hence the whole problem of plant layout.

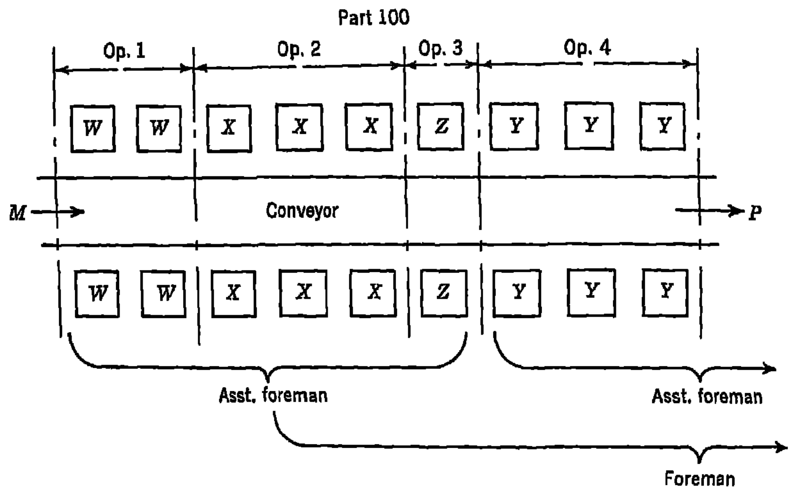


Fig. 10.9. Operative Functionalization Based on Product Characteristics

General manufacturing policy is usually an important factor in plant layout. Our policy governing whether we shall make or buy certain parts for our product is an example. There is no plant layout problem for the part, obviously, if we decide to buy our entire requirements from an outside parts manufacturer. The basis of policy is principle. There are plant layout principles. They are the basis of the policy of the plant layout section in the manufacturing methods department. They guide its work. This section is a technical staff group. Its policies are not general manufacturing policies, obviously. Some of the more important plant layout principles may be summarized as follows.

1. General manufacturing policies condition operations, and should be determined before the plant is laid out.
2. The volume of each kind of work that must be done in a normal work period governs the amount of each kind of productive capacity that must be supplied. Accurate business forecasts are important, in consequence.

3. Information concerning the manufacturing requirements of products and processes should be as complete as possible.
4. The relation of new and improved equipment to the economy of manufacturing should be considered before making the plant layout.
5. Economy of production depends on the provision of adequate space for the storage of work, the operation of machines, and the movement of work.
6. There should be a minimum movement of work between operations.
7. Work should move toward the final assembly operation, the storerooms, or the shipping department with a minimum of backtracking. It should move in a straight line in so far as practicable.
8. Materials-handling equipment is important. Its use should be planned in conjunction with the layout and servicing of equipment.
9. Service centers, such as tool grinding centers, facilitate operations. They must be located accordingly.
10. Machine capacity and man power should be balanced between operations and departments as far as practicable.
11. The physical relations between equipment and facilities should be sufficiently flexible to permit its adjustment to changing manufacturing requirements with a minimum of time and expense. These adjustments may be made necessary by expansions or contractions in the volume of work beyond that forecast, the changing character of work, the secular growth of the business, etc.
12. The requirements of operations and their relation to the general manufacturing environment must be considered in making the plant layout.

Product characteristics may be a very important factor in plant layout, in addition to their effect on sales demand. A concern whose volume of business is large, but consists of a limited number of items of low unit cost and small bulk, may be able to regularize production by manufacture to stock. This is particularly true when the demand for the items is relatively inelastic; when they are not perishable or affected by a style factor, or do not depreciate rapidly in value with storage for other reasons. A soap manufacturing concern is an example. Manufacture to stock has certain advantages. A given volume of business can be handled with a lower investment in plant and equipment. Labor turnover is usually lower. A smaller working force is required. The investment in inventories is higher, on the other hand, and the inventory turnover rate is correspondingly lower. The reverse of this situation tends to be true when a company finds it necessary to manufacture directly to its demand curve. The automobile manufacturer, for example, has a product that is standard only for the life of the annual model. His sales volume is large, which facilitates business forecasting. He must manufacture directly to his demand curve, however, because of the bulky nature of his product, its high unit cost, and the importance of the style factor in the marketing of

automobiles. He has, furthermore, a product that is still subject to rapid technological change. It is evident that product characteristics, as well as sales volume and general company policy, affect the amount of equipment, storage space, and other facilities that must be provided. They have a direct effect on plant layout, in consequence.

Labor and machinery are provided for the performance of various mechanical functions or operations in the manufacture of component parts, and their assembly into finished products. Management must know what parts and subassemblies are needed for each product, how many are required for each unit of finished product, and the rate of production for each within a given unit of time. It must also know the operations that must be performed on each part, subassembly, and final assembly, and the kind, type, and size of the machines required for each operation. When the capacity of each machine is known, the determination of the number of machines required is relatively simple, as we shall see shortly. The production of component parts feeds the subassembly operations; the production of subassemblies and other component parts, in turn, feeds the final assembly operations, in which finished products are produced. Inasmuch as work should progress steadily in the same general direction toward final assembly, and should move a minimum distance from one operation to the next, the assembly relationships between component parts, subassemblies, and finished products are important factors in plant layout. Information relating to them must be compiled before a layout can be planned, and it is usually procured from operating executives and engineers in the plant. The general nature of these relations is shown in Fig. 16.7.

There are other plant layout factors that have not been discussed. Some of them were listed above. The general nature of their force and effect in the problem will be seen when we look at the method of plant layout.

The Method of Plant Layout

The objectives of plant layout will vary between companies, depending on the characteristics and requirements of the product, the volume of business that must be handled, the type and kind of manufacturing that is most economical, and other factors that have been noted previously. The specific details of the method of plant layout will vary accordingly. The general method of approach tends to be common to manufacturing plants, since it is based on certain fundamental principles of plant layout. Some of them have been noted previously. Plant layout is a

management problem that falls in the field of manufacturing methods. The general method of approach may be summarized in terms of the basic management functions. Its application to conditions of continuous manufacturing is usually easier to understand. The following approach is based on such conditions:

A. *Creative Planning*

1. *Marketing Research*

2. *Product Planning, Design, and Development*

3. *Process Planning*

a. *Operation Layout*

b. *Machine Selection*

c. *Tool Design*

d. *Plant Layout*

1. The determination of the quantity of production of the particular part, subassembly, or final assembly for which we must provide productive capacity.
2. The determination of the number of machines or work places of the right type and size that are required for each operation on the part or assembly.
3. The allocation of space and the development of a flow plan for the part or assembly
4. The determination of the best location for each work place, machine, and conveyor in the space allocated on the factory floor plan.
5. Technical approval of the layout plan by the technical staff executive in charge of plant layout, and line approval by the operating organization.

B. *Organizing*

1. *Installation of the Method*

a. *Setup and Acceptance of the Layout*

1. The millwright's section of the maintenance department sets up the equipment, in accordance with the layout plan, on the authority of a work order.
2. The responsible line department executive signs the millwright's work order, thereby accepting the setup as operable and satisfactory. The executive is now accountable for results, in so far as they depend on operating conditions.

C. *Controlling*

1. *Secondary Staff Control*

a. *International Staff Coördination of the Work of Plant Layout*

1. The progress of the work of planning and organizing must be co-

ordinated through each of the preceding steps. We probably are required to start shipping finished product by a scheduled date.

D. *Executing*

1. *The Operation of the Equipment, as Installed, by the Line Department*

Before the plant can be laid out, top management must make a quantitative determination of the primary service objectives. It is the hope, of course, that the new models will improve the company's competitive position. To do this, these models must give the public increased value at the same price, the same value at a lower price, or additional values that are commensurate with any necessary price increases. (This statment is subject to modification, of course, with regard to monopoly, inability of the public to determine quality accurately, etc. In general, however, it tends to be true.) We have probably done some work in market and product research and product design to this end. We have studied also the problem of processing with a view to developing economy in operation. But how many can we sell—one thousand or one million? The answer obviously is vital to our solution of the plant layout problem. It is not entirely a matter of business forecasting. A new model presents the additional difficulty of predetermining its probable reception by the public. We may use all the facts and business science at our command, but the final answer necessarily involves the exercise of qualitative judgment to a considerable degree.

We shall assume, for a concrete case, that our problem is the manufacture of a new model known as Model A. Top management's judgment is that we shall be able to distribute approximately 300,000 units of this model during the coming manufacturing year. This judgment is based on our annual forecasts, together with supporting marketing studies. Like most businesses, ours is subject to the effects of seasonal, secular, and cyclical variation. Taking them into account for the coming year, we estimate that we shall be required to distribute these products at the rate of 40,000 units per month during the peak months. The industrial engineering department has been directed to plan for a production of 85 percent of peak sales.

We shall assume also that the detailed work of designing and testing the various parts, assemblies, and finished products is in process. Blueprints, bills of materials, product specifications, etc., are being released for each part or assembly as soon as the designing is completed satisfactorily. They are sent to other line or staff departments in the organization including industrial engineering, when properly approved. Some of

this information, such as assembly relationships and the interchangeability of parts between models, enters directly into the layout problem.

Processing creates certain form utilities in the product by effecting some physical or chemical change in certain materials. The term "processing" refers to the performance of those primary operative functions that result directly and immediately in a desired change in the form or state of materials. It may be affected by certain secondary operative functions such as tool grinding, inspection, internal transportation, storage, and other service functions. A production plan for a part or assembly is merely a statement of the conditions that are required for the proper performance of operative functions on a part or product, and the relations between them. It provides an effective and economical basis of action for the creation of the desired utilities. The determination of the characteristics and requirements of these utilities is, of course, a function of product design. The part or assembly will not function satisfactorily in the finished product without them. The creative planning of process has to do with the original determination of what operations must be performed on each part or assembly, their sequence and the time required to perform each operation, the most economical and effective method of moving work between operations, and similar information. It requires the consideration of alternative methods of processing; the possibility of eliminating or combining operations; the use of jigs or fixtures to increase productive capacity, improve quality, or make it possible to use less skilled workers; the relation of operation sequence to the movement of work through and between departments; and related problems.

We probably have a heavy investment in machinery and equipment. Its characteristics vary between specific items with regard to the kind, quantity, and quality of work that it can produce, its adaptability to new operations, the extent to which our investment has been amortized, etc. We must determine whether it is more economical to buy newer and more productive machinery and to displace certain equipment that we own at present—decisions which directly affect the plant layout.

We shall assume that these decisions have been made, and the process design functions of operation layout, machine selection, and tool design have been performed, for part 100 of Model A. We have been asked to plan the production line for part 100 that was shown in Fig. 10.9. The person responsible for the layout of this part has received certain process information on a form that is similar to the one shown in Fig. 9.7. Inasmuch as there is sufficient volume to permit us to set up our equipment for straight-line production, all operations will be performed in the same

department.[10] The general space requirements for this department have been allotted. It has been located in one of our plants in accordance with the basic assembly relationships of the product. Because of the characteristics of the demand, the necessity for annual models, the high unit cost, and the large bulk of the product, it is necessary to work rather closely to our demand curve. There is some flexibility, however, for we can manufacture for stock to a limited degree in advance of the peak season and can increase the hours of work moderately for a short period of time. Our design orders require us to tool up for a peak production of 34,000 units of Model A per month, on the basis of a working month of 160 hours. The master plan of work for part 100 shows that 5 pieces are required to assemble one unit of Model A. We must tool up, consequently, for a peak production of 170,000 pieces per month. The plan of work shows also that we use a W-type machine on operation 1 for the part; that the standard production time for the operation, including tool changes, is 0.175 minute per piece.

Machine capacity usually is expressed in terms of machine-hours. The time, in hours, necessary to complete an operation on a part, multiplied by the total number of parts that are required during a period of time, gives the total capacity required of the type of machine to be used. The number of machines required for the operation may be determined by dividing this figure by the number of hours that one machine will run during the period. It is not possible, however, to get the total capacity out of any machine; no management can ever entirely eliminate machine breakdowns, failure of the materials supply, excessive scrappage of work, and the other interferences with production. Consequently, the theoretical capacity of a machine must be reduced by some production factor which takes such interruptions into account.

The relationships between these factors, and their values in this case, may be expressed as follows:

$$N = \frac{T \cdot P}{60 \cdot H \cdot F}$$

[10] There will be minor differences in required process information. Figuro 9.7 is a production plan for a part that is made under conditions of intermittent manufacturing. This is indicated by the routing of the part to different departments for successive operations. Limited quantities are manufactured on a production order as needed. A specific allowance for setup time is given. The progress of the order is followed through the operations and departments on its operation list. These are not the conditions for continuous manufacturing.

The problem of part 100 is somewhat oversimplified by the fact that it is used only in the assembly of Model A. Most concerns try to develop interchangeability of standard parts between models, wherever possible.

in which:

N=the number of machines required for the particular operation.
T=the standard time per piece for the operation, in minutes. (it is 0.175 min/pc, in this case.)
P=the maximum production per month that is required. (It is 34,000×5, or 170,000 pieces per month, in this case.)
H=number of hours worked per man or per machine, per month. (We have assumed that the standard working month is 160 hr/month.)
F=a production factor, or factor of use, that is frequently estimated to be 0.8. (It should be determined by analysis of previous production records.)

We can easily determine, on the basis of the above information, the number of machines that will be required for operation 1 on part 100:

$$N=\frac{0.175\times 170{,}000}{60\times 160\times 0.8}\text{, or 3.87 W-type machines}$$

When continuous production is conveyorized, as indicated in Fig. 10.9, it is not feasible to apply a fraction of the capacity of a machine to an operation. Therefore we must apply 4 machines of this type to operation 1. This example shows several reasons why it is not possible to get an exact balance of capacity, even with a large volume of production.[17]

Before attempting to determine the exact location for each machine, production line, or assembly line, it is usually desirable to make flow sheets for each part and assembly. A general flow plan for a plant is shown in Fig. 10.10. A diagram showing the routing and flow of work for part 100 may be made in addition. We could proceed directly to locate individual operations and machines, but the preliminary analysis of space and flow relationships usually saves considerably more than the time and expense of making it. The general locations and directions of the lines of flow are based on the general assembly relationships that must be maintained in the manufacture of the product. Such diagrams aid greatly in determining the locations of operations and departments, the adequacy of any general space allotments that have been made, and the general characteristics of the equipment layout within them.

We shall assume that certain bays in a building have been assigned to the manufacture of part 100. The manufacturer's catalogue shows that each W-type machine requires approximately 10 square feet of floor space. If a flat-roll conveyor is used, it is usually necessary to increase this space

[17] This is why it becomes uneconomical to lay out a plant for straight-line production when the volume of sales or the production requirements for a part drop below a certain level. The utilization of machine capacity drops rapidly. It becomes more economical, at some point, to use a layout similar to the one shown in Fig. 10.8.

requirement about 2½ times to provide room for the conveyor, the machine operator, machine repairs and adjustments, etc. No space is needed for work in process because such work is stored on the conveyor between operations. The above applies to light machine-tool operations and does not provide space for main aisles. The depth of the work area from the center line of the conveyor is usually about 8 feet. In this case, machines are located on both sides of the conveyor. If we represent by the symbol L the distance along the flow line for part 100 that is covered by operation 1, then,

$$L = \frac{10 \times 4 \times 2.5}{8 \times 2}, \text{ or approximately 6.25 ft.}$$

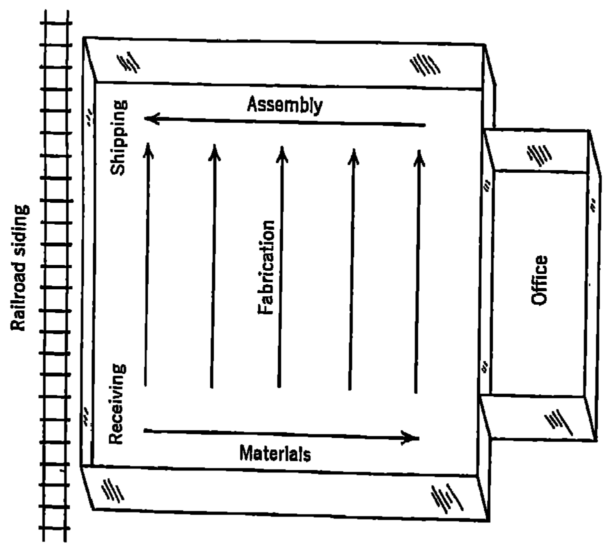


Fig. 10.10. A Flow Sheet for Use in Plant Layout

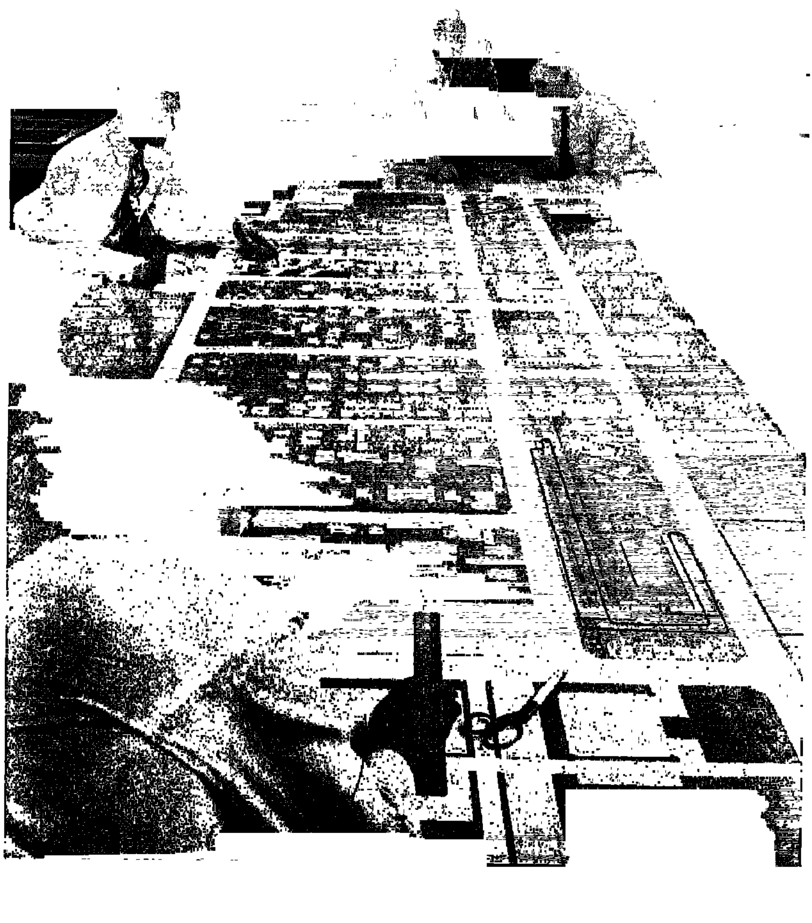
If the original space allotment for this part was correct, we shall be able to use the bays that have been assigned to it. However, we may find that it is necessary to turn the flow in various ways in order to do so. We shall keep the work progressing steadily forward toward the inspection, subassembly, and final assembly points, but we may not be able to achieve a straight-line flow in a strict mathematical sense.

To some extent, the final determination of the best location for each machine or other equipment is the result of trial and error. Templates representing actual space requirements for each item of equipment are drawn on cardboard to the same scale as the floor plan of the area in

which the machines are to be located. These templates are cut out and pinned to a blueprint of the floor plan in the general locations indicated by the flow sheet for the job. These are then arranged and rearranged until what appears to be the most effective relationship is obtained. This phase of the method of layout is illustrated by Figs. 10.11 and 10.12.

When the final layout for the job has been completed, a pencil tracing usually is made. In most cases, it is an unnecessary expense to make an India-ink tracing on tracing cloth, or to dimension it, for millwrights can scale a blueprint of the tracing with sufficient accuracy for their purposes. The plant layouts for a large company may be drawn up by a plant layout section. An examination of the tracings and prints will show frequently a number of signatures on them; these represent the approval of the staff executives who are responsible for the layout plans, and the line executives who are responsible for the departments in which the particular parts or products are to be made. We cannot hold a line organization account-

Fig. 10.11. Arranging Templates for a Plant Layout. (Courtesy, The General Motors Corp.)



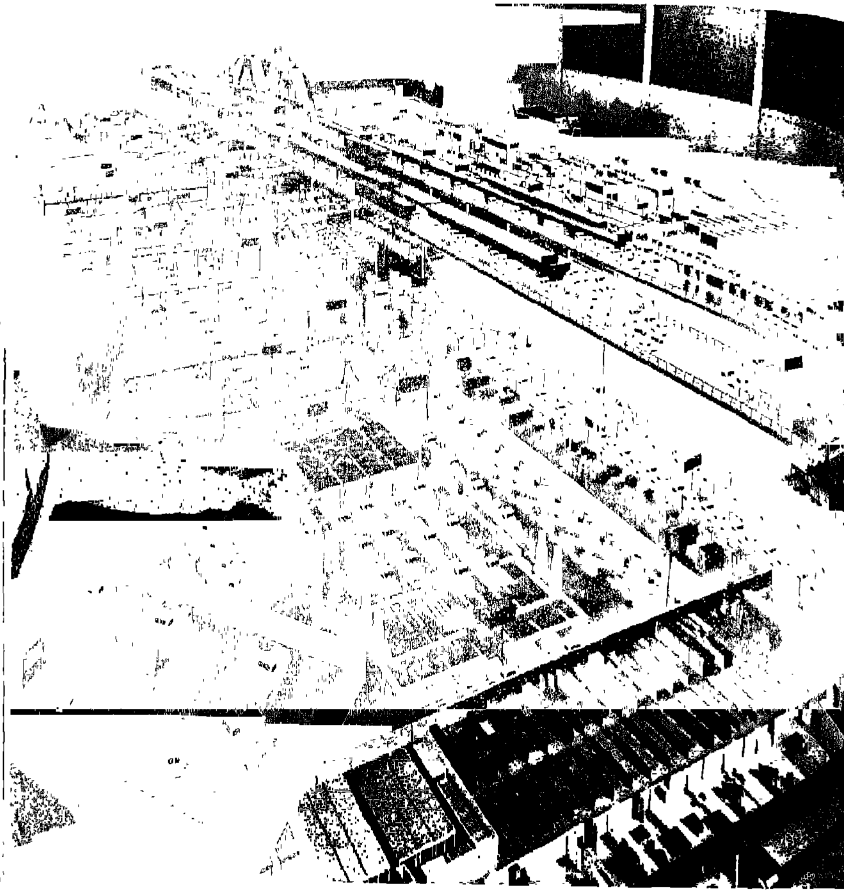


Fig. 10.12. A Master Layout for the Dodge Assembly Plant. (Courtesy, The Chrysler Corp.)

able for results unless it can make the final decisions on which results depend. As we noted in our discussion of staff functionalization, a staff organization is appended to and serves a line organization. A staff organization cannot control a line organization on the basis of staff authority. Hence the signatures.

After the final tracing has been approved, blueprints will be made and sent probably to the millwrights' section in the maintenance department. The millwrights will move the specified equipment to the locations indicated, and set it up in accordance with the layout plan. When they have done this, they must get an O.K. from the plant layout section and acceptance by the department foreman, which releases them from their responsibility. When the new department or section is approved by the production division, we are ready to go into production of part

100, at least in so far as the proper physical relationships between manufacturing equipment and primary operative functions are concerned. We shall probably be required to get these O.K.'s in writing on some prescribed form, to prevent any shifting of responsibility later on.

Perhaps the problems of the plant and its equipment have been discussed in more detail than is justifiable in an elementary discussion of management. It is necessary to understand the contributions of these factors to economy in manufacturing. It is more important, to realize that the work of planning and organizing the use of these factors conforms closely to the basic principles of organization and operation that have been discussed previously.

PROBLEMS

1. A small company is engaged in the manufacture of metal novelties. The line includes a wide range of items, and is constantly changing because of the changing whims and fads of the public. Quality standards are not high, however. Most of the operations involve blanking, drawing, forming, piercing, or crimping of sheet metal. Because the items are small and a light-gauge metal is used, light, high-speed sheet-metal presses are employed. Their operation involves considerable vibration. Although the company is growing rapidly, its financial condition is weak. Its limited finances have been invested in inventories, some new equipment for the expansion of its productive capacity, and in promoting the distribution of its products. The company's credit position is not established to a degree that will permit it to secure unlimited loans. Its present plant is inadequate and obsolete, however. The management feels that a new plant must be built. Good industrial plant sites are available in the community where the company is presently located at approximately $1500.00 per acre.
   (a) Assume that you are a member of a committee that has been appointed by the president of the company for the study of the plant and equipment problem. It is the function of this committee to consider various staff studies of this problem that will be made, and to recommend a solution. The committee is expected to integrate the thinking of our principal executives concerning the problem. The committee may develop an agreement concerning the criteria of a sound solution. It may then set up a number of possible solutions for study and report by staff agencies within the company's organization. What tentative solutions would you suggest, within the limits of the data that have been given? What additional facts would be helpful? How could they be obtained?
   (b) What principles are important to policy decisions concerning plant construction; the procurement of new equipment; the relocation of plant sites?
2. The time needed to complete a given operation on a certain part is 0.2

minute. The production required per month is 500,000 pieces. The plant normally runs 8 hours per day and 20 days per month.

(a) Using a production factor of 0.8, compute how many machines will be required for the operation.

3. The Sawyer Furniture Company manufactured a line of medium-quality wood furniture, mainly wooden tables, desks, and chairs. It had enjoyed an annual increase in sales volume of about 5% for the last 6 years. Management found itself faced with increasing competition, however, in a market characterized by rising prices and a somewhat unsteady demand. The president had heard that some television manufacturers had successfully automated assembly lines for television units, and that certain automobile producers had effectively automated certain phases of manufacture and assembly of their products. He believed that the installation of automated equipment was worth investigating. He felt that the operations involved up to the point of finishing and painting could be automated, if proper attention were given to equipment design. While the investment in automation would be substantial, the results, he felt, would likely justify the major change-over. In addition to minimizing labor costs, a substantial cost item, the quality would be uniform. With production problems minimized, management could devote more time to distribution problems.

(a) Evaluate the president's thinking concerning the need for and effects of automation. What are some of the prerequisite conditions for an economical use of completely automated operations?

(b) What factors must be taken into consideration in determining a policy for automation in a manufacturing plant?

CHAPTER 11 •

• Materials Handling

Materials Handling and Manufacturing Economy

INDUSTRIAL materials handling is the work of moving and positioning materials that is performed within the physical confines of an industrial enterprise, at a particular location. We may be engaged in multiplant operation, in which various plants are dispersed geographically. The term "materials handling" refers usually to the problem of moving materials within the yard, warehouse, manufacturing areas, or office areas of a particular plant or factory. The work of moving worked material or finished product between factories at different geographical locations, or to customers, is regarded usually as a phase of the traffic manager's function.

Much of the work of operative employees has to do with the handling or movement of raw, worked, or finished materials. When purchased materials are received, they must be moved from the cars or trucks in which they are shipped, to the floor of the receiving department. After they have been checked in, they must be moved to a storeroom or to production. In the storeroom, they must be moved to the point of storage, and frequently they must be handled as they are piled, stacked, or stowed. Their subsequent release to the point of use requires movement, and probably handling. The previous chapter pointed out that much of the primary operative work of production had to do with or was directly affected by materials handling. In consequence, the provision of materials-handling equipment has to be considered in connection with plant layout. The problem of materials handling begins, as a rule, with the receipt of materials into the plant. It ends only with the shipment of the finished product. It is necessary, in some industries, to move from 50 to 100 tons of material for each ton of finished material that is shipped. There have been cases in which the use of improved materials-handling equipment

and methods has increased production from 10 to 50 percent.[1] Materials handling is an important factor in economy in manufacturing for such reasons. It is evident that the movement of materials within a plant takes place between points of receipt and storage of materials, between points of storage and use, at or through these points of use for processing purposes, to points of storage or shipment in the case of finished stock. Materials-handling problems can be classified accordingly.

Objectives

Some types of materials-handling equipment are expensive. The development and installation of improved methods often raise some difficult problems, and may interfere seriously with current operations. Therefore the materials-handling system must produce values that are commensurate with the expenditures of time and money required for its introduction and operation. The objectives of good management have been noted previously. They are: (1) an improved competitive position as a result of better customer service, (2) a rate of profit that is above average for the industry as a result of higher capital turnover and lower costs, and (3) higher organizational morale. The personal objectives of either owners or operatives cannot be satisfied for any long time unless these objectives are accomplished continuously and satisfactorily.

Staff planning of materials-handling installations is a phase of process planning. Its objectives are derivatives of management objectives. They are values that are necessary for (1) improved customer service, (2) better quality of product, (3) better utilization of plant and equipment, (4) higher capital turnover, (5) greater economy in storeroom and warehouse operation, (6) lower operating costs, (7) better man-power utilization, (8) better morale, and (9) more effective production control.

A good materials-handling installation may contribute to improved customer service by making possible a faster movement of raw and worked materials. The result is shorter production lead times. It may be possible, in consequence, to promise prompt delivery of the customer's order without the expense of overtime work. This may be possible even though the plant is operating at shift capacity and inventories of finished product are below normal. A good materials-handling system may reduce the number of customer back orders, because it provides a positive, depend-

[1] It has been estimated by C. J. Carney, Jr., Managing Director, Society of Industrial Packaging and Materials-Handling Engineers, that most consumer products would cost from 40% to 100% more if modern materials-handling equipment and methods had not been developed. See article by Betty Savesky in the August, 1950 issue of *Commerce*. Other estimates have indicated that materials-handling costs account for 30% to 50% of manufacturing costs.

able means for moving materials at a scheduled rate. There are many products whose quality may be damaged by careless or improper handling. Any metal part with highly finished, accurately ground surfaces may be an example. These surfaces can be marred by improper handling in the course of movement between operations. The quality attributes of the product are those that enable it to satisfy customer needs and desires. There may be costly losses, due to scrappage of low-quality parts that are damaged in transit, as well as loss of customer satisfaction.

A fast, reliable materials-handling system contributes usually to a more effective utilization of plant and equipment. The banks of work in process that support the operations of a production line or production are in part an insurance policy against materials-delivery failures. The size of such banks, and the amount of factory floor space that is required for them, can be reduced by increasing the speed and reliability of materials delivery. Work in process is carried on conveyors, as much as possible, in the continuous manufacture of assembled products. This inventory of work in process is off the floor, and is moving much of the time. Figure 11.7 shows a carrousel conveyor serving a flat-belt conveyor in light assembly work. Component parts and subassemblies are stored on trays in the air, and the assembled product is stored on the belt conveyor between operations. Provision for floor storage obviously is unnecessary. A similar situation is shown in Fig. 17.5, in which a production line is served by a flat-roll conveyor, the worked materials being stored on the conveyor and moved between operations in steel tote boxes. Work may be moved also between departments or plants by overhead conveyors, rather than over plant floors. We are able to place a larger number of machines in a given plant area, in consequence. It is often possible to move materials up to machines or production lines, and position them conveniently for use. This is shown in Fig. 11.3. Less time is spent in the preparatory phases of machine operation. We increase the proportion of machine running time to total working hours. This tends to increase the production per machine per day. Plant and equipment represent usually a large proportion of our fixed capital. Our inventories in stores and in process represent usually a large proportion of our current assets. Anything that will increase the rate of production per square foot of factory floor space, or speed up the movement of inventories, will tend to increase the rate of capital turnover per dollar of sales. The capital-turnover rate is a basic factor in profit making. Top management usually has a keen interest in the possible contributions of materials-handling equipment to this objective.

Materials-handling equipment and methods can improve the economy

of storeroom and warehouse operations in many ways. The supply division of a manufacturing plant may include the receiving, stores, internal transportation and shipping departments, in addition to certain others that are concerned with the supply problem. There is a continuing movement of raw and worked materials from the receiving dock, through the receiving and stores departments, into production or supporting staff operations. Purchased materials are stowed temporarily in appropriate storage facilities. Finished or semifinished materials may be received into stores from production operations. These materials must be moved subsequently, on proper orders, to assembly departments in the factory, or to the shipping department for shipment to the customer. The volume of movement of these materials depends, of course, on the volume of sales. The cost of moving materials through our stores operations is relatively an important cost factor in manufacturing, nevertheless. A few examples will show the cost reduction possibilities in storeroom operations through the use of materials-handling equipment. There is frequently some competition between the production organization and the stores organization for available factory floor space, when we are not overbuilt. The stores department is usually charged for the use of space in any event. The cost of its operations obviously can be reduced by storing more materials on less floor space. One solution is to pile materials to greater heights by means of appropriate materials-handling equipment. An example of such practice is shown in Fig. 21.11. It may be possible to handle more materials with less labor by storing direct materials in the same containers in which they will be moved into production or shipped to the customer. An example of this practice is shown in Fig. 21.9. There may be an internal transportation section or department within the stores organization. It may be responsible for the movement of materials from stores to operative departments, as requisitioned. This material must be where it is needed, when it is needed. A positive, reliable transportation system is necessary for the discharge of this responsibility. An example of materials-handling equipment for internal transportation purposes is shown in Fig. 11.13. Other examples of the contributions of such equipment to the economy of storeroom and warehouse operations will be seen later, when we look at the work of the supply division.

Many of the above developments result in lower processing costs, as well as lower handling charges. The use of materials-handling equipment will result frequently in a substantial reduction in the labor cost of materials handling. The work is done largely by a machine that can move more material faster than can a man. The machine is not subject to

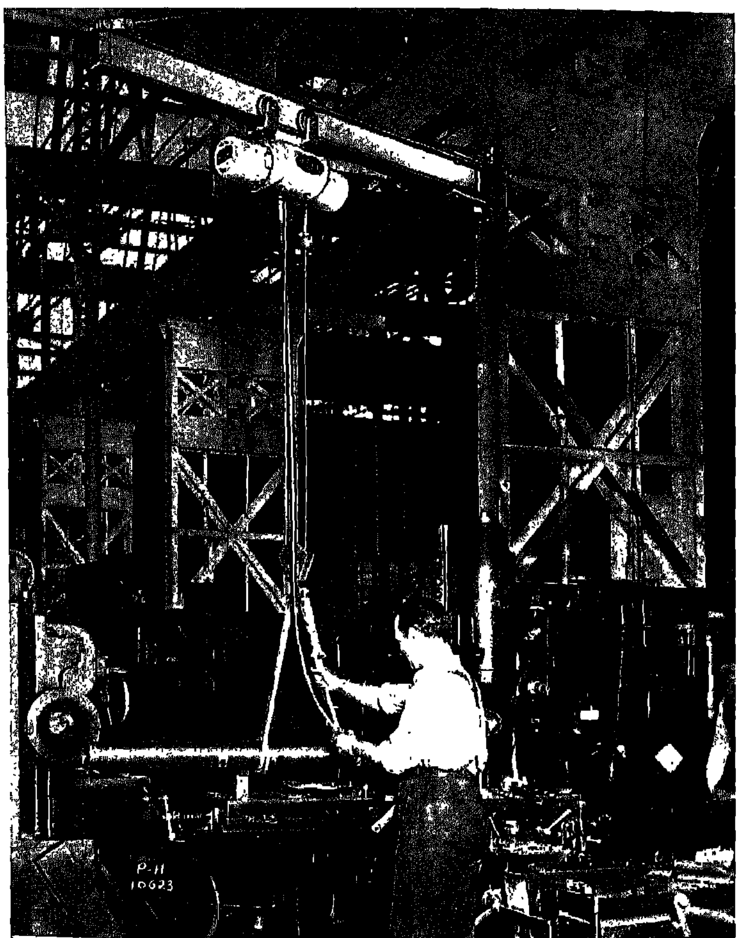
fatigue, of course. The savings in the labor cost of materials handling may be sufficient to pay for the equipment in a short time. The faster handling of materials results in lower interest charges and other handling costs. The hourly rate of a machine may be higher than the wage rate of the man who runs it. A reduction in the amount of machine down time due to delivery failures, or an increase in the amount of operating time of the machine due to a better handling of materials at the machine, may make substantial cost savings.

Many cost savings are the result of better man-power utilization. Operative employees are able to work faster and more effectively, because the physical labor of handling and moving materials is reduced greatly. At the beginning of this century, pig iron was being handled by hand at the Bethlehem Steel Company, and elsewhere throughout the country. Frederick W. Taylor, who was employed by the company at that time, became interested in the problem. One result of his investigation was the discovery that a first-class workman, handling a 92-lb pig of iron, could be under load only 43 percent of the working day; he must be entirely free from load during the remaining 57 percent of the time. A more fundamental result was Taylor's discovery of the law of heavy laboring: "For each given pull or push on the man's arms it is possible for the workmen to be under load for only a definite percentage of the day."[2] Pig iron is lifted and moved today by materials-handling equipment, at much lower cost. It has been noted in continuous manufacturing that operatives tend to synchronize their pace of work with the speed of the conveyor, or the rate of flow of production, provided that the rate is not excessive. The result is a steadier pace of work that is at or near the optimum rate of production. Materials-handling equipment tends to integrate men and machines in a productive unity. Such integration promotes coöperation provided that the other conditions of good morale are present. The ability to develop good morale depends largely on ability to develop and show a direct relation between the interests of the employee and the service objectives of the organization. Leadership is probably the most important morale factor. The writer had some contacts, during World War II, with a plant in which the labor utilization was approximately 55 percent. The employees had about half as much work as they could and should do. Their respect for and confidence in their executive leadership was low, because of the poor utilization of labor, and so was morale. A steady, fast, uninterrupted flow of work is concrete evidence of effective accomplishment and competent management. A good materials-handling system

[2] F. B. Copley, Frederick W. Taylor, Vol. ii, p. 41, Harper & Brothers, 1923.

is an important factor in such a flow. An increase in directly productive time of the operative as a result of a reduction in the indirectly productive time required to stack and lift work at the machine depends on the use of materials-handling equipment. The personal interests of the employee are benefited directly by a reduction in the amount of such work. The working life of the employee is extended, since it depends less on the continuation of his physical powers. In many lines of work, older men would have an advantage, as long as they retained their mental vigor, because of their greater experience and better judgment. The electric hoist mounted on a jib crane, in Fig. 11.1, is being used with a vertical milling

Fig. 11.1. A Jib Crane with an Electric Hoist, Serving a Vertical Milling Machine. (Courtesy, The Harnischfeger Corp.)



machine. With its aid, the operator can pick up a heavy piece from the floor with little physical effort, and land it on the bed of his machine. Without mechanical assistance, he would have to lift it by his own strength, with consequent danger of injury to himself. If it were too heavy, he would require the assistance of one or more nearby mechanics; their machines would be idle while they were helping him, which would mean additional expense for the company, and lower *per capita* production. Safe working conditions are as important to the employee as they are to the management. An intelligent application of materials-handling equipment usually contributes to the development of conditions such as these.

More effective production control is not usually the principal objective of a materials-handling installation. It is evident, nevertheless, that a steady, continuous, reliable movement of work, as routed, increases the accuracy and effectiveness of production control.

Principles and Policies

A principle has been defined previously as a statement that is accepted as a truth, which expresses some meaningful relation between cause and effect. A business policy is a statement of business principles, and their supporting rules of action, that set up some causal relation between business objectives and the functions and factors which enter into their accomplishment. Principle is the basis of policy. The objectives of materials handling in industrial establishments have been discussed above. These values will not be accomplished satisfactorily unless the work of materials handling is performed economically and effectively, using proper equipment. This means that it must be performed in consonance with the requirements of sound principle, policy, and practice. We are not concerned here with the principles that underlie the design of materials-handling equipment. Such design is the responsibility of the engineer. The space limitations of a general text, such as this, prevent also the discussion of the various special principles and rules that enter into the operation of particular kinds of equipment. We are concerned chiefly with materials-handling principles and policies that govern the selection of equipment and the planning of materials-handling systems, that govern the work of organizing for the installation of such a system, that govern the economical and effective operation of the system when it has been installed. Production, purchasing, and stores executives should understand these principles, as well as our manufacturing engineers. The following are examples of some that may furnish a basis for the formulation of materials-handling policy.

1. There should be a minimum movement of materials between departments and operations.
2. Materials should be moved continuously, at a maximum rate, as far as possible.
3. The capacity of the materials-handling equipment should be equal to the volume and rate of movement of materials, in order that the equipment will not bottle-neck operations.
4. The size and characteristics of the load determine the size and type of materials-handling equipment that should be used for greatest economy.
5. Production control is facilitated by a dependable materials-handling system that will move materials as scheduled.
6. The amount of production by men and machines is increased by transferring the physical work of moving and positioning materials to materials-handling equipment.
7. The rehandling of materials should be reduced to the necessary minimum.
8. The overhead movement of work releases floor space for productive work.
9. The equipment and methods that are selected for handling a particular item of materials should preserve whatever quality has been built up in the item previously.
10. Standard equipment that has the flexibility required by the particular materials-handling problem should be used whenever it is economical.
11. Control of the use and movement of materals-handling equipment should be established, to assure its maximum employment in the particular materials-handling system.
12. Materials-handling equipment should pay for itself within a limited period of time, that is established by company policy, to assure against loss through obsolescence.

The materials-handling problem should be studied in conjunction with plant layout, to the end that the number of moves of a given material, and the distance moved, may be reduced to a minimum. In this connection, it should be remembered that the materials-handling problem begins with the receipt of raw materials and supplies, and ends only with the shipment of the finished product.

The maintenance of a continuous, uniform, maximum rate of movement of work in process is a requisite for maximum economy in production. The rate must be consistent with the type of manufacturing, the capacity of the equipment, and the well-being of the employees. Therefore materials should move continuously between and through the operations, whenever possible. An example of this was shown in Fig. 11.2. The proper application of this principle usually speeds up the movement of work in process inventories and increases their turnover. In some cases, *per capita* production is increased as a result of a reduction of congestion at work places. Floor space may be released if the conveyor carries much of the work-in-process inventory, and if the necessity for large banks of

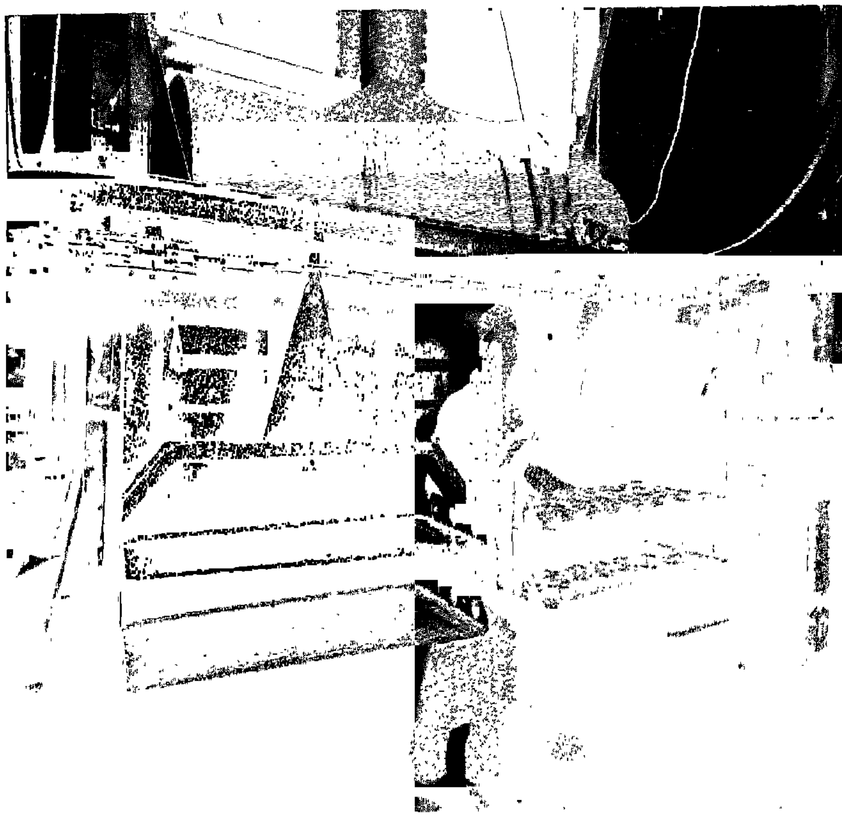


Fig. 11.2. Overhead Monorail Chain Conveyor in the Plant of the Case-Moody Pie Corporation, Which Handles Pies at the Rate of 6000 per Hour. (Courtesy, Link Belt Co.)

work is reduced by a more efficient movement and more positive control of materials. The continuous movement of materials introduces rhythm into work; this usually reduces fatigue, makes work more pleasant, improves morale, and increases *per capita* production. However, materials-handling equipment is more likely to cause bottlenecks, interferences, and irregularities in the flow of materials than to eliminate them, unless its capacity is equal to that of the men or machines that use it. In this connection, the size and characteristics of the load to be transported or stored are important factors in materials handling, for they affect the type of equipment that should be used. It will be seen later that the control of production in continuous manufacturing depends largely on the control of the movement of materials to the production or assembly lines. Plants engaged in this type of manufacturing take into account the manner of transporting and storing materials, the type of equipment that is best

suited in view of the volume of materials to be moved, the size of a unit load, the frequency of deliveries, and other similar factors. The deliveries of materials from the storerooms are likewise carefully scheduled and controlled.

In so far as the work of production is concerned, materials-handling equipment can probably be used economically wherever heavy physical exertion is required in the movement or handling of materials. As a general rule, loads of over 100 pounds should be handled mechanically, although there may be cases in which lighter loads may be handled more economically by this means. Materials-handling equipment speeds up the handling of work at and around the machine and saves the employee from the effects of fatigue, thereby increasing the output of the machine. An application of this principle was shown in Fig. 11.1. It is evident that there is a direct relation between materials-handling equipment and motion economy in operative functions.

Each materials-handling operation requires some expenditure of time, money, and effort. In consequence, the rehandling of materials should be reduced to a minimum. This principle is illustrated in Figs. 21.11 and 11.3 (the use of the pallet and truck system in storing) and 11.3 (the use of the truck and skid system in production). Wherever practicable, the ceiling should be used for the handling and movement of materials, rather than the floor. Overhead materials handling, such as the monorail telpher (Fig. 21.13), avoids traffic congestions and releases floor space for productive purposes.

The quality of materials and products must frequently be considered in the selection of handling equipment. Highly finished surfaces, difficult contours, accurate dimensions, and other attributes are expensive to create. Serious waste may result if they are damaged subsequently through mishandling.

The materials-handling system must have sufficient flexibility to permit effective and economical service over the normal range of variation in manufacturing conditions within the plant. In general, its flexibility tends to vary inversely with the extent to which it is designed to serve a special purpose, but the necessity for flexibility usually decreases as the standardization of manufacturing conditions increases. When conditions can be highly standardized, special-purpose equipment may be entirely justified by its greater efficiency in the particular materials-handling task. It is obvious that the flexibility of equipment tends to decrease, the more its operation is limited by physical restrictions. For example, if it must be anchored on concrete foundations, or must run on tracks, or for other

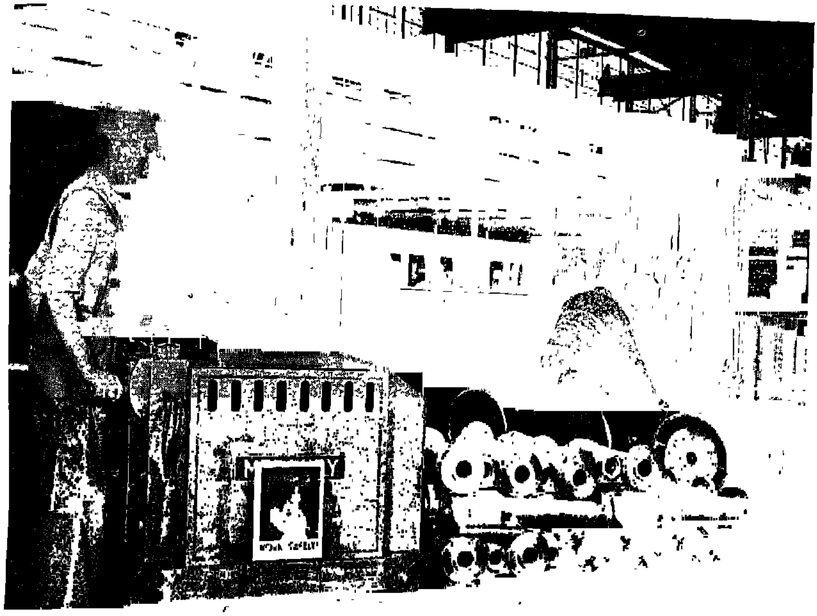


Fig. 11.3. A Power-Driven Low-Lift Truck with Skid, Delivering Work in Process to a Drill Press. (Courtesy, The Mercury Mfg. Co.)

reasons cannot be moved about easily, it may not be able to meet the materials-handling service whenever and wherever it arises, as well as can a general-purpose type of trackless transportation of the same capacity. In most cases, flexibility, mobility, and portability go together. The first cost of special purpose equipment is higher usually than standard equipment. Maintenance costs may be higher also.

The operation of a materials-handling system requires a substantial investment in equipment. We should get a good turnover of this investment also. This means that we should approximate full employment of equipment at maximum capacity, as closely as practicable. This requires the continuous use of equipment with a minimum of idle time. The internal transportation section, in some plants, routes and schedules such materials-handling equipment as industrial trucks, tractors, and trailers. Some companies have established two-way radio communication between equipment operators and a transportation control station. This is similar to the practice of the taxicab companies, of course.

Finally, the monetary savings from an installation of materials-handling equipment should be sufficient to amortize it at a rate that will preclude obsolescence. There may be cases in which a certain kind and quality of service must be had, regardless of cost, but this is not usually the case. A common policy is to require the amortization of standard equipment by depreciation charges and net savings, within approximately two years.

Principal Functions

The principal materials-handling functions have to do with:

1. The movement and positioning of materials for purposes of warehousing and storage
2. The internal transportation of materials between points of storage or use within the organization.
3. The movement of materials within departments for purposes of temporary storage or positioning for use at the machine or workplace.

Warehousing and storing requires the handling and movement of large quantities of materials of all kinds. Some of them are purchased materials. Some are expense materials of various kinds. Others are raw materials for production. These materials are moved from the common carrier, through the receiving department into stores. There the materials must be stored safely, pending subsequent disbursement on proper authority. Storing sometimes involves the handling and movement of large amounts of loose or bulk materials. Fig. 11.4 shows malt being moved from a barge to a warehouse by a pneumatic conveyor. Some goods are packaged and must be stacked or piled properly. An idea of the handling problems involved is given by Fig. 21.5, which shows the storage of bulk packaged materials in a warehouse. Materials-handling equipment conditions stores economy in many ways.

There is a constant and complex movement of materials, usually between warehouses and storerooms to the plants and departments that use them. Direct materials in a semifinished condition are moving between various line departments for further processing. Finished parts are moving to storerooms, pending later disbursement to assembly departments. Finished product is moving to finished stores or the shipping department for shipment to the customer. It is evident that there is a difficult job of internal transportation to be performed. It cannot be performed properly without suitable materials-handling equipment. Fig. 11.13 illustrates the general nature of this problem of interdepartmental and interplant transportation.

The movement of materials within a department can be broken down

Fig. 11.4. A Pneumatic Conveyor, Used to Move Malt from Barge to Warehouse. (Courtesy, Holly Pneumatic Systems, Inc.)

into three principal phases: the temporary storage of materials within the department, the positioning of tools or materials in preparation for processing, and the movement of materials through the processes. Figure 11.3 illustrates the temporary storage of worked material at a machine. Figure 16.6 shows a die being set in a sheet-metal press. Figure 11.1 shows an operative landing a piece of work on the table of a vertical milling machine, with the aid of an electric hoist that is mounted on a jib crane. Figure 10.7, illustrating automation, shows also the conveyorized movement of cylinder blocks by means of a conveyor through the operations that are being performed on them.

Kinds and Classes of Equipment

There are many kinds and types of materials-handling equipment. Different kinds may serve different purposes. Sometimes different kinds may serve the same purpose, but not in the same ways or with the same efficiency. The differences between kinds of equipment are significant to the extent that they condition its ability to move or position materials in a manner that will meet the requirements of the particular materials-handling problem. The purpose of any classification of any set of factors is to bring out the significant differences between them. It is evident that a classification of materials-handling equipment can be helpful in selecting the right piece of equipment for the right purpose.

The basis of classification that is selected is a matter of judgment: it depends on what are the dominant functions and factors that should be emphasized in the particular problem. The following are five bases that may be used.[3]

1. Classes of apparatus, such as cranes, hoists, conveyors, and lift trucks.
2. Nature of service performed: lifting, transporting, etc.
3. Nature of the material handled, such as loose or bulk, pieces or parts, packages, bundles, boxes, and barrels.
4. Major fields of industry, such as mining, manufacturing, transportation, and construction.
5. Relative mobility of equipment, with reference to its ability to move in a fixed path, travel in a limited area, or travel over wide areas.

The classification of equipment that is given below cuts across some of the above bases. It brings out, nevertheless, some of the significant differences in the work of materials handling.

a. Hoisting machinery, including cranes
b. Package-handling equipment

[3] L. P. Alford, and J. R. Bangs, eds., *Production Handbook*, The Ronald Press Company, 1944, p. 942.

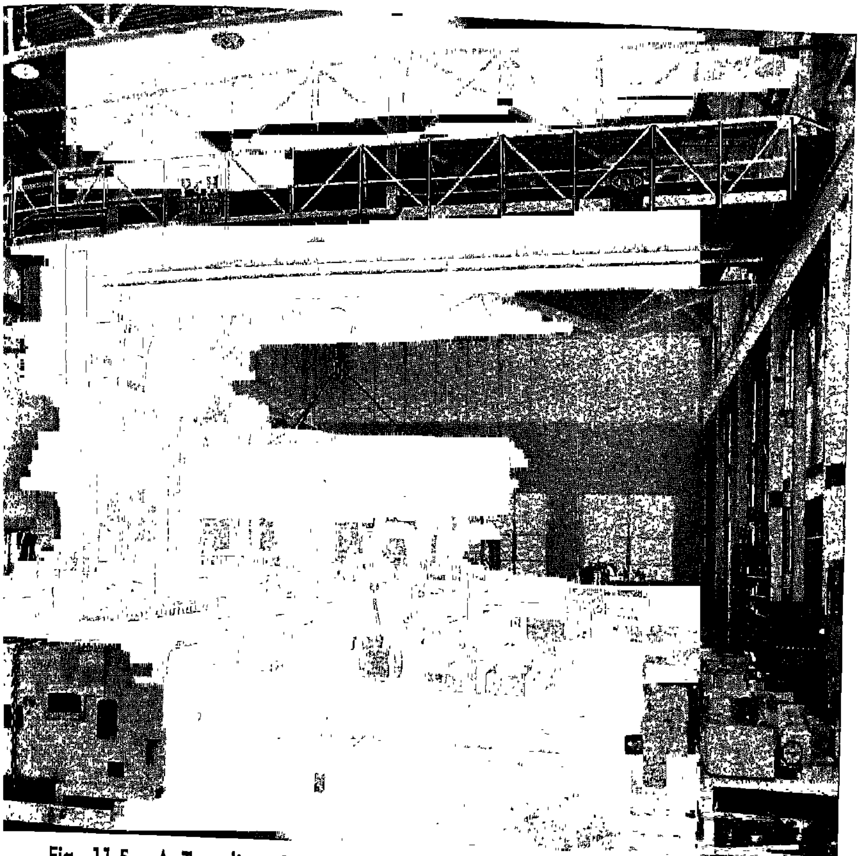


Fig. 11.5. A Traveling Crane Moving Large Castings in a Machine Shop. (Courtesy, The Harnischfeger Corp.)

c. Conveyors for loose materials
d. Industrial elevators
e. Trackless transportation
f. Industrial rail transportation

HOISTING MACHINERY

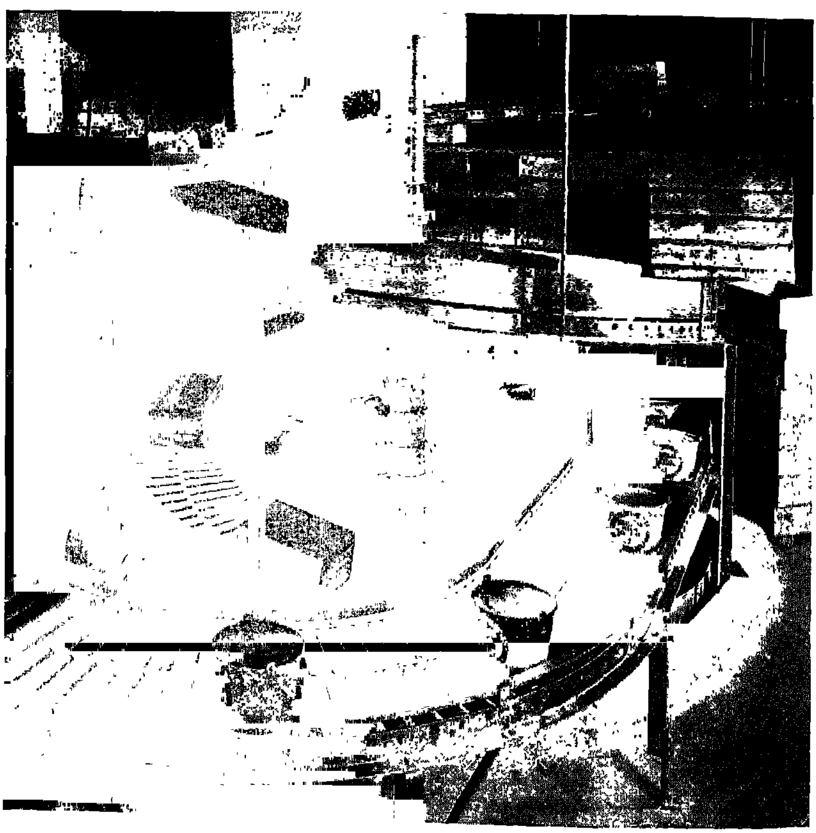
This classification includes tramways and excavating equipment, in addition to various types of cranes and hoists. A great variety of cranes and hoists are used in industry. Traveling cranes of the type shown in Fig. 11.5 are well adapted to the movement of heavy loads over considerable areas, either in large shops or in storage yards. While heavy-duty cranes are operated from a cab, very light traveling cranes may be electrically controlled from the floor. A gantry crane used in the yard storage of heavy, bulky materials is illustrated in Fig. 21.2. Figure 21.5 shows a light crane equipped with an electric hoist, in use in a large warehouse.

In most cases, hoists are used to lift and handle heavy, bulky materials locally. They may be used in conjunction with some other type of handling equipment to transport such materials. We shall see some examples of this shortly when we discuss package-handling equipment. An electric hoist mounted on a jib crane was shown above in Fig. 11.1. An interesting application of a portable hand-operated chain hoist is shown in Fig. 13.3; it is being used by maintenance mechanics in tightening the belt of a live-roll conveyor.

PACKAGE-HANDLING EQUIPMENT

This classification includes a wide variety of equipment, such as flat-roll, gravity-roll, and live-roll conveyors. It includes belt conveyors, slat and platform conveyors, carrousel conveyors, monorail chain conveyors, telphers, push-bar elevators, and chutes. Package-handling equipment is

Fig. 11.6. Spiral Gravity-Roll Conveyor. (Courtesy The Logan Co.)



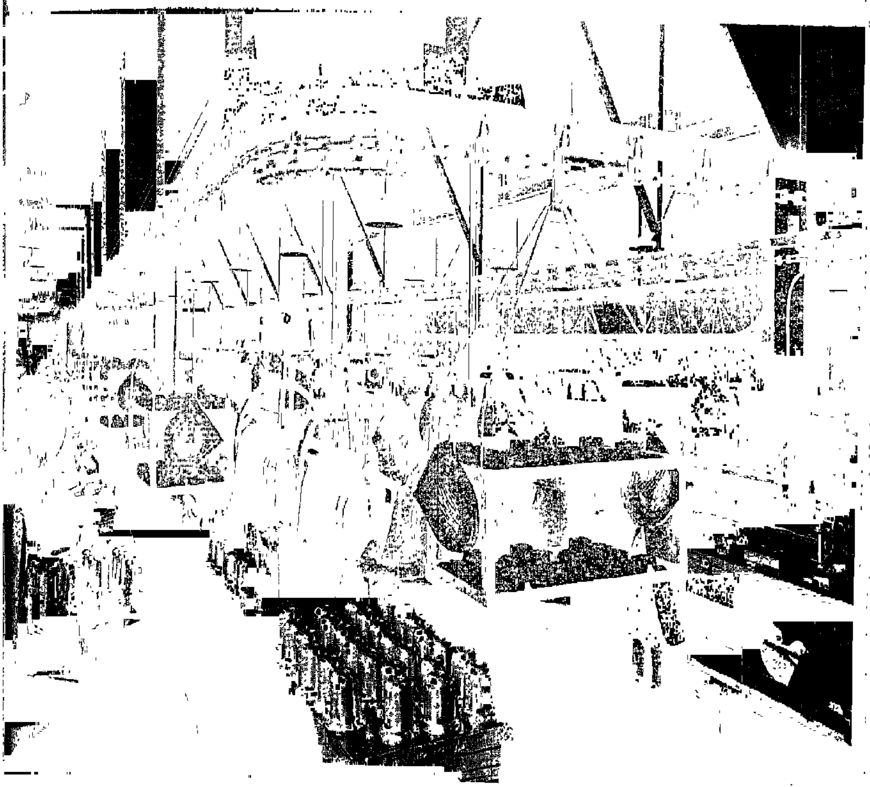


Fig. 11.7. A Flat-Belt Conveyor, Served by a Carrousel Conveyor in Light Assembly Work. (Courtesy, The Lamson Co.)

used commonly in the continuous handling and transporting of specific units of materials in volume. These units may be individual items such as castings, containers holding definite quantities of worked materials, goods that are packaged and transported in barrels, crates, boxes, etc. In other words, the materials are in such form that they may be handled and transported as individual packages. As the following examples suggest, such equipment is used more frequently and more extensively in process or continuous assembly industries than in intermittent assembly industries. Roll conveyors are a common example. The principal types—flat-roll, gravity-roll, and live-roll conveyors—are used in all kinds of manufacturing industries. Figure 17.5 shows the use of flat-roll conveyors and steel tote boxes in a production line set up for the continuous manufacture of connecting rods for gasoline engines. The rolls are mounted on ball or roller bearings and of course spin easily. When a workman completes a tote box of work, he gives it a shove, and it rides along the conveyor to the

next operation. Figure 11.6 shows a system of spiral gravity-roll conveyors. The system of live-roll and gravity-roll conveyors shown in Fig. 21.6 is used in connection with the movement and storage of oil drums in a refinery. The construction of a live-roll conveyor is shown in Fig. 13.3. The belt is cut and laced to give the proper belt tension, and is held against the rolls by means of idlers. The crates on the conveyor move in a direction opposite to that of the power-driven belt. Materials can be transported continuously over long distances, inasmuch as their movement does not depend on gravity or human power.

Flat-belt conveyors also give continuous delivery, and in some cases compete with live-roll conveyors. These conveyors are used frequently for individual items for which smooth delivery on a soft, smooth surface is essential for the protection of quality. Flat-belt conveyors are well adapted to the handling of materials between light assembly operations. Such conveyors may be used to elevate materials, provided the angle of elevation is not too great. Figure 17.10 shows a flat-belt conveyor used in packing confectionery.

Slat conveyors provide a broad, fairly continuous surface that can stand up under hard use. Figure 11.8 shows this type in use in the continuous assembly of refrigerators. The loader piling sacks of grain in Fig. 21.4 is

Fig. 11.8. Shipping End of a Slat Conveyor Used in the Final Assembly Line of a Refrigerator Manufacturer. (Courtesy, The Standard Conveyor Co.)

a common type of portable slat conveyor. A competing form of equipment that has greater capacity and flexibility is a portable screw conveyor for handling sacked materials. Power-driven platform conveyors are just what their name implies. These usually consist of platforms, running in tracks, that are linked together by a power chain. They are used frequently in continuous foundries because the broad, flat surfaces of the platforms are well adapted to the transportation of molds from the molding machines to the pouring stations, through the cooling tunnel, etc. Figure 17.7 shows an interesting application of a platform conveyor that serves assembly, crating, and shipping operations.

Certain types of package-handling equipment permit the overhead handling of materials. These types make possible the speedier transportation of particular materials, relieve congestion in the flow of materials through the aisles of factory departments, and enable the more effective use of factory floor space in the storage of materials. The three types noted —carrousel conveyors, monorail chain conveyors, and telphers—are frequently used in manufacturing plants, particularly in those engaged in continuous manufacturing. A carrousel or merry-go-round conveyor consists of a power-driven chain that travels on a monorail track. Hooks, trays, baskets, or similar devices are suspended from the chain. The path of the track is not necessarily circular, but it usually covers a relatively limited area. A common application is in the continuous assembly of relatively small mechanical products. An example is shown in Fig. 11.7. The conveyor passes through a substorage area, or loading station, that is contiguous to the assembly line. The various parts required for assembly are placed in the appropriate receptacles and travel down the line at a speed that is usually about twice that of the assembly conveyor—a flat-belt conveyor in Fig. 11.7. As the receptacles pass the successive assembly stations, each assembler takes the material needed for his particular operation. The empty receptacle returns to the loading station. If a particular item is not needed at the moment, it continues to ride on the merry-go-round until needed. The monorail chain conveyor shown in Fig. 11.2 is used in a pie factory. It can handle production at the rate of 6000 pies per hour. So far as the details of construction are concerned, this type of conveyor is similar to the carrousel. However, it is quite different functionally, for in most cases it handles and transports worked materials continuously through the successive steps in the fabrication of a product, rather than its assembly. A telpher is a cab-controlled, power-driven hoist, usually electric, that runs on a monorail track. Figure 21.13 shows one that is being used to move wire from a warehouse to a gondola for shipment.

Such equipment is capable of handling heavy loads speedily between widely separated points. By supplying suitable trackage and switching devices, it can be given sufficient flexibility to enable it to cover any area. This equipment lacks flexibility, in so far as ease of adjustment to changes in plant layout is concerned.

Some forms of package-handling equipment may be used to raise or lower materials between floors. We have noted previously that belt conveyors may be used to move materials up light gradients. By special manipulation of their hoists, telphers also have been used to move materials between floors without rehandling. A more common device is the pushbar

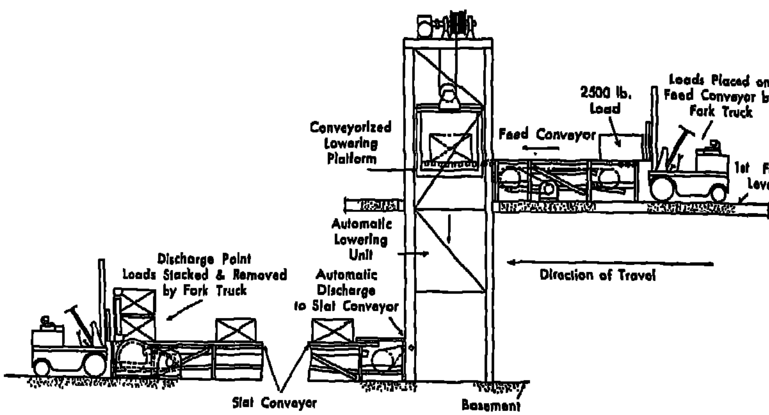


Fig. 11.9. An Industrial Elevator Application at the Continental Can Company's Baltimore Plant. This system handles 2500-lb. bundles of steel sheets automatically. (Courtesy, The Gifford Wood Company.)

elevator shown in Fig. 21.1. This type of conveyor consists of two strands of chain, connected at intervals by crossbars. The example shows its use in conjunction with a short length of gravity-roll conveyor to move materials from a receiving dock to the storerooms above. Packaged materials, in this case, are pushed up a sheet steel slide that is almost vertical. Some installations use a belt conveyor, in which case the speed of the belt and of the pushbars must be the same. Spiral or straight chutes are often used to move packaged materials downward between floors. The installation shown in Fig. 21.8 combines a flat-belt conveyor, a portable chute, and the pallet system for storing bulk packaged materials. The chute is equipped with a deflector to divert the packaged material from the belt. This combination has considerable flexibility, as well as large capacity.

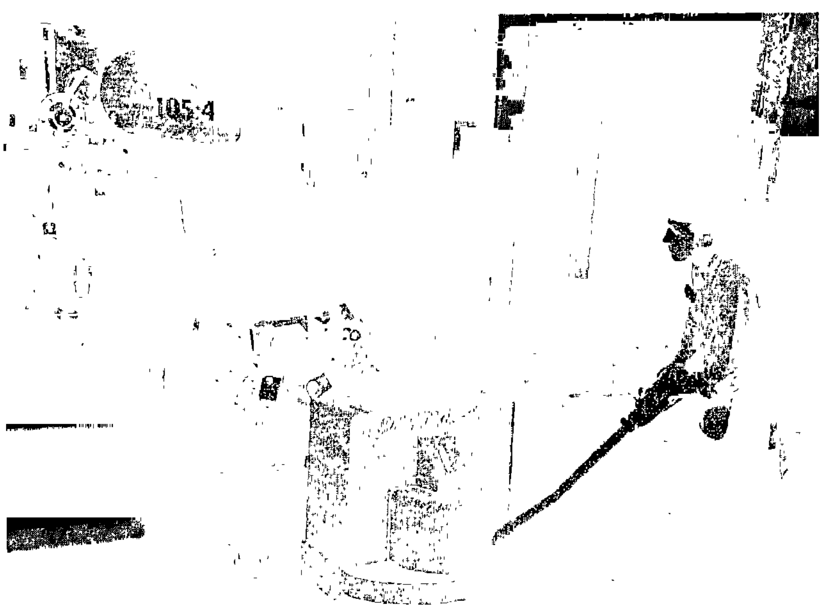
CONVEYORS FOR LOOSE MATERIALS

This classification includes skip hoists, screw conveyors, continuous bucket conveyors, gravity conveyors, belt conveyors, and pneumatic conveyors. Materials-handling systems employing some combination of skip hoists and continuous bucket conveyors are commonly used in industrial powerhouses for handling coal. Industries whose raw materials are in loose bulk form must use this type of equipment. Figure 11.4 illustrates pneumatic equipment for moving malt from a barge for storage in a brewery. When large quantities of liquid materials are used, they are usually conveyed by being pumped through pipe lines. Although process industries such as soap manufacturing plants pump their materials, the best-known example is the oil companies, who convey crude oil to the refineries over hundreds of miles through their pipe lines.

ELEVATORS

Specialization in the vertical movement of materials is the common characteristic of industrial elevators. They range from large passenger or

Fig. 11.10. Hand-Lift Truck Moving a Load of Castings Through a Narrow Aisle to a Drilling Machine. (Courtesy, The Clark Equipment Co.)



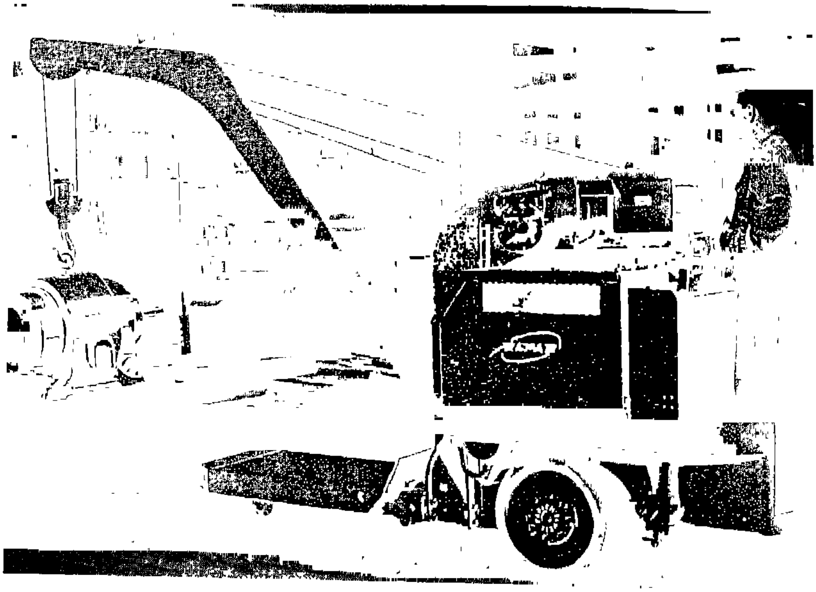


Fig. 11.11 An Industrial Truck Equipped with a Crane. (Courtesy, The Elwell Parker Electric Co.)

freight elevators that require the services of an operator, to automatic elevators for handling particular kinds of materials. An example of the latter is shown in Fig. 11.9. It may be regarded as special package-handling equipment for the vertical movement of materials. Such elevators can be set to discharge automatically at any desired floor. Portable hand-operated elevators are often used in storing materials, but they have been superseded to a great extent by elevator trucks or other competing equipment.

TRACKLESS TRANSPORTATION

This class of equipment includes platform trucks, hand trucks, lift trucks, storage battery or gas trucks and tractors, truck cranes, and trailer cars. They serve a variety of purposes. Their principal advantages are speed, mobility, and flexibility. They can go almost anywhere within the plant, and handle almost anything within the limits of their capacity. Devices that must operate on tracks or from a fixed position necessarily are less mobile and flexible. Trucks and tractors differ greatly in their characteristics, depending on the requirement of the materials-handling problem. Some trucks are hand powered. Tractors are power driven. Some that must operate over rough terrain are equipped with caterpillar treads. Some tractors may have three wheels or four. This affects the radius in which they can turn. This radius is sometimes important in connection

with aisle widths and corners. Platform trucks are an important subclassification of trackless transportation. Hand trucks fill an essential need where it is necessary to move loads locally within a radius of approximately 200 feet. Hand dollies are found frequently, but they have been largely displaced in manufacturing by hand lift trucks of the type shown in Fig. 11.10. Lift trucks are used in conjunction with skids, as shown. This combination affords maximum flexibility. For anything except local and usually intradepartmental transportation, the power-driven truck is likely to be most efficient and economical. It may be powered by either a gasoline motor or an electric storage battery. Such trucks may be classified as low-lift or high-lift platform trucks, and elevator or tiering trucks. We have already seen, in Fig. 11.3, a power-driven low-lift truck that is used for the delivery of materials to a drill press. The platform of the truck may be run under the skid and elevated to give sufficient clearance to permit the transportation of the load through the shop; this represents about the limit of its elevating capacity. Of course, materials may be stacked in containers or piled directly on the platform, but this necessitates an addi-

Fig. 11.12. An Industrial Truck Equipped with a Ram for Moving Rolls of Sheet Metal. (Courtesy, The Elwell Parker Electric Co.)

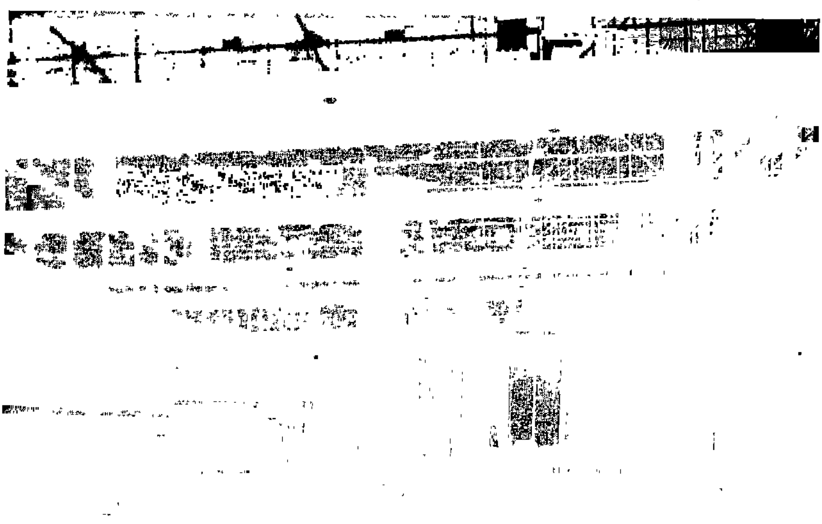


Fig. 11.13. An Industrial Tractor Moving a Trailer Trainload of Forgings Between Departments. (Courtesy, The Clark Equipment Co.)

tional rehandling operation. The high-lift truck generally has a rigid structural steel column that is an integral part of the truck frame. The platform may be elevated approximately to the height of this column. This equipment is quite adequate if lack of headroom or the nature of the material limits piling to about 8 feet. An elevator or tiering truck, such as that in Plate 21.11 has an extension column that telescopes within the main column when not in use. The platform may be elevated approximately to the height of the extended column. In general, the greater the elevating capacity that is required, the more costly is the truck. Furthermore, industrial trucks are often built with special equipment when some specialization of function is desirable. Figure 11.11 shows one equipped with a crane. When ferrous materials must be handled, the hook sometimes is replaced by an electromagnet. Industrial trucks in rolling mills are often equipped with rams for handling sheet metal, as shown in Fig. 11.12. All high-lift trucks do not have fixed columns. In some it is possible to tilt the load slightly by tilting the column. This type of truck, with special attachments, has been used successfully for handling heavy rolls of paper in the printing and paper industries. Tractors are used extensively for hauling loads between plants or widely separated departments.

Figure 11.13 shows an industrial tractor moving a trailer trainload of forgings between departments in a plant.

INDUSTRIAL RAIL TRANSPORTATION

The last classification, industrial rail transportation, includes locomotives, cable cars, and hand-propelled cars. They hardly require comment. Most people have seen small industrial locomotives operating in the yards of large manufacturing plants. These locomotives are used to spot freight cars at the receiving docks, to move loaded cars away from the shipping docks, and for similar purposes. These are the most common examples of this class of equipment in manufacturing industries.

The Analysis of Materials-Handling Economies

An analysis of materials-handling economies requires an investigation of the cost factors that enter into both the present and the proposed methods. The savings to be produced by the new equipment should be capitalized at a rate sufficient to cover equipment maintenance, interest, depreciation, obsolescence, taxes, and other fixed charges. The amount of the capitalized savings represents the maximum that can be spent on the equipment. Most concerns feel that this kind of equipment must pay for itself within a relatively short time, usually 2 years. The time may vary, however, with the type of equipment and the nature of the installation. This may appear to be an unreasonably severe test. Materials-handling equipment frequently must operate under unfavorable conditions. It must stand hard use. Its utility is dependent on the characteristics and requirements of current manufacturing functions. These are changing constantly. The fact that manufacturers have always been aggressive in the development of their products increases the danger of obsolescence.

The American Society of Mechanical Engineers has developed certain formulas for estimating the economies that are possible with the application of certain equipment to a materials-handling problem.[4] The following factors in handling costs are taken into account, and are indicated by letter.

A—Percentage allowance on investment
B—Percentage allowance for insurance, taxes, etc.
C—Percentage allowance for maintenance
D—Percentage allowance for depreciation and obsolescence
E—Yearly cost of power, supplies, and other items, in dollars

[4] They were presented originally before the ASME at Milwaukee, in May, 1925, by George E. Hagemann and James A. Shepard, in a paper entitled "Formulas for Computing the Economies of Labor Saving Equipment."

S—Yearly saving in direct labor cost, in dollars
T—Yearly saving in fixed charges, operating charges, or burden, in dollars
U—Yearly saving or earning through increased production, in dollars
X—Percentage of year during which equipment is used
I—Initial cost of the equipment

The relations between these factors are expressed by the following formulas.

Z, the maximum justifiable investment, in dollars

$$=\frac{(S+T+U-E)X}{A+B+C+D}$$

Y, yearly cost of maintaining ready for operation

$$=I(A+B+C+D)$$

V, yearly profit from the operation of the equipment, above simple interest

$$=[(S+T+U-E)X]-Y$$

P, the estimated rate of profit

$$=\frac{V}{I}+A$$

H, number of years required for amortization of investment out of earnings

$$=\frac{100}{P+D}$$

A simple example will illustrate the general approach. We shall assume that the full time of 3 men is required for the interdepartmental movement of work in process by means of hand trucks. The work is unskilled and is paid at the rate of $1.00 per hour. Deliveries are irregular and unsatisfactory. A study of delays in production shows that those attributable to poor deliveries and congestion of work in process cost the company about $875.00 per year. The management believes that at least this much can be saved through the mechanization and better organization of interdepartmental transportation. The study may find that a motor-driven lift truck can handle all this work. The best truck for their purposes will cost about $4500.00, and its operator will earn about $1.25 per hour; there will also be an operating cost for gas and oil not necessary for the hand truck. It is estimated that the new truck will use about 0.33 gallon of gasoline and 0.028 gallon of oil per hour, costing $0.25 and $1.50 per gallon, respectively. Operating on a 40-hour week, the factory runs approximately 2000 hours per year at the maximum. Current business conditions are such that it will not average more than 85 percent of this figure. The management allows 4.5 percent to cover insurance and taxes, and estimates the expense

of maintenance and repairs at 15 percent. With good maintenance, the equipment should have a life of 5 years. Savings must cover at least 6 percent on the investment. Burden is charged against indirect labor at the rate of 20 percent. On this basis,

$S = (2000 \text{ hr} \times \$1.00/\text{hr} \times 3) - (2000 \text{ hr} \times \$1.25/\text{hr})$ or \$3500.00/yr
$T = \$3500 \times 0.20$, or \$700.00
$U = \$875.00$, from elimination of expense of production delays
$E = (2000 \text{ hr} \times 0.33 \text{ gal/hr} \times \$0.25)$
$\quad - (2000 \text{ hr} \times 0.028 \text{ gal/hr} \times \$1.50)$ or \$249.00
$X = 85\%$
$I = \$4500.00$
$(S+T+U-E)X = (\$3500.00 + \$700.00 + \$875.00 - \$249.00)0.85$, or \$4102.10
$(A+B+C+D) = (6\% + 4.5\% + 15\% + 20\%)$, or 45.5%

Therefore $Z = \dfrac{\$4102.10}{0.455}$, or \$9015.60. The cost of the equipment, installed, is well within this limit.
$Y = \$4500.00 \times 0.455$, or \$2047.50
$V = \$4102.10 - \$2047.50$, or \$2054.60
$P = (\$2054.60/\$4500.00) + 0.06$, or $0.457 + 0.06$, or 0.517
$= 0.517 \times 100$, or 51.7%
$H = \dfrac{100}{51.7+20}$; or 1.39 years, approximately, to amortize itself.

This investment should be safe, as well as quite profitable. It conforms to the policy that the investment must write itself off within 2 years.

PROBLEMS

1. The management of a company has received a recommendation that a hand-operated device for handling materials be replaced by a power-operated machine. The new equipment will cost approximately \$1,450.00, and the cost of operating it, exclusive of labor and maintenance, is estimated to be \$300.00 per year. The present equipment requires two unskilled laborers who receive \$1.60 per hour; the new equipment will require one semiskilled operator at \$2.00 per hour. The plant is not expected to average more than 1800 hours of work during the coming year. The company's accounting department makes a burden charge of 15% against indirect labor. It is estimated that the new equipment will be in operation approximately 80% of the time throughout the year. It is not anticipated that it will make any appreciable contribution to increased production. In purchasing equipment of this type, it is the company's practice to charge 5% on the investment, 4.5% for insurance and taxes, 15% for maintenance and repairs, and 20% for depreciation and absolescence.
   (a) Assuming that these allowances are approximately correct, should you approve this recommendation? Why or why not?
2. A firm used several kinds of chemicals in its manufacturing processes. These

materials were delivered to the firm by freight car in 200-lb drums. They were stored in an open shed in the yard area, about 500 yards from the factory buildings. Drums were generally loaded manually on motor trucks by members of the yard crew. They were delivered in lots of ten or twelve to the factory entrance, where they were deposited on the factory floor. The employees who operated the processes then picked up the drums individually as they were needed. These employees used handcarts, or "dollies," to move the drums to the process area where they were emptied.

(a) Suggest various ways in which improvements in materials handling could be made in the above case. What are the benefits of your suggested improvements?

(b) What principles of materials handling can be applied in this situation?

CHAPTER 12 •

• Lighting and Air Conditioning

The Importance of Good Illumination

MANAGEMENT is interested in good illumination because it aids greatly in the achievement of certain business objectives. These objectives include such values as increased *per capita* production, better quality, less scrap, fewer accidents, and improved morale. There have been many cases in which the installation of a modern lighting system has increased production by amounts ranging from 10 to 30 percent, and sometimes more. Quality has to do with the development of certain attributes, such as form, finish, color, dimension, strength, etc. Illumination may be a very important factor when the creation of these characteristics requires close, careful attention to detail. The relation of good lighting to quality is obvious in such operations as color-matching. Speed of vision, a factor affecting the individual's speed of reaction in his work situation, tends to increase with the intensity of illumination, beyond the lighting levels usually found in the average manufacturing plant. The employee's ability to proceed confidently, decisively, quickly, and accurately with his work conditions his ability to maintain high production standards continuously, without detriment to his well-being. High wages, both real and monetary, usually depend on the continuous achievement of these standards. Illumination conditions his earning power in some degree, in consequence. Poor illumination, in addition to causing eyestrain because of glare or insufficient light, tends to increase the probability of serious accidents. These accidents may cause a serious loss of earning power and increased expense for the employee, as well as loss of production and increased expenses for the organization. It is evident that good illumination involves several identities between the personal objectives of executives and those of operative employees on the one hand, and the service objectives of the company on the other. It is a factor, accordingly, in the development of morale. It is a factor in manufacturing that conditions performance in

many ways. It receives careful consideration from progressive managements for this reason.

The subject of illumination breaks down into two fundamental phases, natural and artificial lighting. It will be assumed, in discussing these phases that the reader's interest is executive rather than technical. The following information is merely a minimum that a line executive should have to exercise judgment or coöperate with lighting engineers on lighting problems.

Natural Illumination

Natural illumination is that received from the sun through apertures in the building. Daylight is the principal and sometimes the only light that is used during the greater part of the working period. The problem of natural lighting has affected building design and plant layout for this reason. The building is, conversely, a most important factor in the effectiveness of natural lighting. The problem presents two major phases: (1) the admission of sufficient light to make possible a satisfactory intensity of illumination, and (2) the effective utilization of this light to provide a uniform intensity without glare. Solutions of these problems will differ for single-story and multistory buildings.

PROVIDING THE MAXIMUM AMOUNT OF NATURAL LIGHT

The admission of sufficient light is dependent on the number, size, and location of the windows or other apertures. In a multistory building, the effective wall area for natural lighting extends from the bench level to the ceiling. More than 80 percent of this area in modern buildings is usually in glass; with "daylight" construction it is possible to use almost 100 percent.[1] As Figs. 3.1 and 4.1 show, the tendency in modern design is to use a maximum amount of glass in long continuous strips, both for lighting efficiency and for effect.

Low ceilings in multistory buildings usually mean poor illumination. The ratio of ceiling height to floor width should be as large as possible, for more light can thus get to the center of the shop. For example, ceilings should be from 12 to 18 feet high in buildings between 60 and 80 feet wide.

In single-story buildings, or the top floors of multistory buildings, it is possible to provide some means for overhead lighting. This is desirable, of course, because light can then penetrate directly into the center bays of the shop which are difficult to light from the side walls. The usual means of overhead lighting are: (1) skylights, (2) monitors, and (3) saw-

[1] See p. 274.

tooth roofs. The first two are relatively inexpensive to construct. They increase greatly the amount of light coming into the shop. They have the disadvantage of admitting the direct rays of the sun. This tends to cause glare unless special glass is used. Glass block has been used in the monitor in Fig. 10.3 to diffuse light. Though more expensive, the sawtooth construction shown in Fig. 10.2 is more efficient. When it is oriented to the north, a uniform reflected light is admitted evenly over the whole floor. Since the back surface of each tooth should act as a reflector for the tooth behind it, both the interior and exterior surfaces of the sawtooth should be whitewashed or painted white. In the usual sawtooth construction, the depth of each bay is about 25 feet. The area of the tooth face that is in glass should be from 30 to 35 percent of the floor area of the bay, the height of the tooth being governed accordingly.

THE INTENSITY AND DISTRIBUTION OF NATURAL LIGHT

The intensity of light varies considerably in the average multistory factory building. There may be a very high intensity in the areas adjacent to the windows, but the interior of the shop may be so dark that it is necessary to use artificial light even in the middle of the day. This expense is unnecessary. For example, if clear glass is used in the windows, the intensity of light in the floor area within 6 feet of the east windows may exceed 500 foot-candles on clear sunny days, but drop below 100 foot-candles on cloudy days.[2] The intensity in the interior of the shop may be less than 2 foot-candles, despite the high intensity at the windows, because most of the light has been absorbed by the floor and objects near the windows. Most kinds of work require a much higher intensity, as we shall see shortly.

The above conditions tend to produce glare. This is a condition in which areas with a high intensity of light are surrounded by areas in which the intensity is much less. The eye has difficulty in adjusting itself. Such conditions are trying, and quickly produce fatigue. They may affect the quality of work adversely. As is shown in Fig. 12.1, the curve of illumination across a shop in the average multistory building is roughly a broad-based U. The problem is to flatten this curve as much as possible, diffusing and distributing the intense light at the windows evenly over the whole floor area. As we have seen, this problem is largely eliminated in the single-story building through overhead natural lighting.

[2] The unit of illumination is the foot-candle. It is equivalent to the intensity of light from a standard candle at a distance of 1 foot.

THE IMPROVEMENT OF NATURAL LIGHTING CONDITIONS

Many organizations are housed in multistory buildings that are not modern. They may find it inadvisable to build a new plant in the near future. Under the circumstances, what can be done to improve the natural lighting conditions? There are several possibilities. None of them is particularly expensive. These possibilities include: (1) the use of diffusing window glass, (2) good window-cleaning service, (3) the proper treatment of the interior reflecting surfaces, and (4) the elimination of belts driven by overhead line or jack shifts.

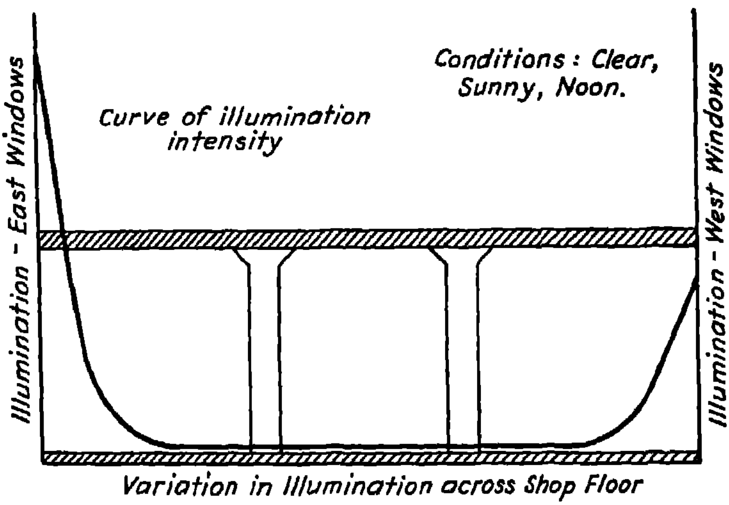


Fig. 12.1. Variation in Illumination Across the Shop Floor

Clear glass is the most efficient from the standpoint of light transmission. Its disadvantage is that the direct admission of daylight concentrates it within a relatively small area, producing glare. There are many special types of glass that redirect and diffuse the light rays. A light-diffusing glass has been used in the building shown in Fig. 10.4. Prism glass bends the light rays, which fall on the window at an angle, so that they pass horizontally into the room. It is seldom used in industrial buildings, however. Ribbed glass or some similar diffusing glass is frequently used as a compromise. Ribbed glass is less expensive than prism glass. It breaks up and diffuses the direct light rays when the ribs run horizontally, redirecting much of the light to the walls and ceilings from which it is reflected to the plane of work. However, it collects dirt, and is hard to keep clean.

The glass blocks which are being increasingly used in industrial buildings act as light diffusers as well as heat insulators.

Much of the lighting value from large, well-located windows equipped with good glass is lost if the windows are not kept in good condition. A thick film of grease and grime on the panes can exclude a large percentage of the light that would normally pass through a window. The window-cleaning service is highly organized in some plants, for this reason.

The ceilings and side walls in a multistory building are important as light reflectors. Much of the daylight that reaches the center of the shop is received indirectly by reflection from them. The efficiency of these reflecting surfaces depends largely on their color treatment. For example, white surfaces will reflect about 80 percent of the light that falls on them, whereas a dark mahogany will reflect only about 8 percent. For this reason, many concerns whitewash or paint their shop interiors white at regular and frequent intervals. Most of the light that falls on the machinery will be absorbed if the machinery is painted with the conventional dead black. Some concerns have specified that new equipment shall be painted in battleship gray.[3]

The machinery, in some shops, is driven by belts running over pulleys mounted on jack shafts or line shafts. A network of belts screens the center of the shop from the windows and prevents much of the light from reaching it. To improve natural lighting as well as reduce the expense of moving machinery, the trend among manufacturing concerns is toward individual motor-driven equipment. The expense of operating and maintaining a large number of small motors may be greater. It is offset by the reduced expense of plant layout changes, as well as improved lighting.

Artificial Illumination

Sometimes the artificial illumination is poor in plants in which the natural lighting is good. Yet some artificial illumination may be necessary from 10 to 40 percent of the working period, depending on the latitude, the season of the year, the weather, and natural lighting conditions in the shop. In considering the problem of artificial illumination, a number of

[3] The writer recalls a visit to the plant of a nationally known manufacturer. It was a beautiful sunny day in early summer, but every electric light in the shop was burning, and still there was a depressing half-gloom. The sickly yellowish light coming from windows that apparently had not been washed in months was stopped effectively by hundreds of belts reaching to the ceiling, and by bulky machines that were without exception painted black. Up to a level of about 4 feet the walls and columns were painted a drab brown so that dirt and grease would not show conspicuously; above, the color was indeterminate. Yet the buildings were modern. It is definitely not good management to make an expensive investment to secure good light unless one expects to maintain the equipment in good condition.

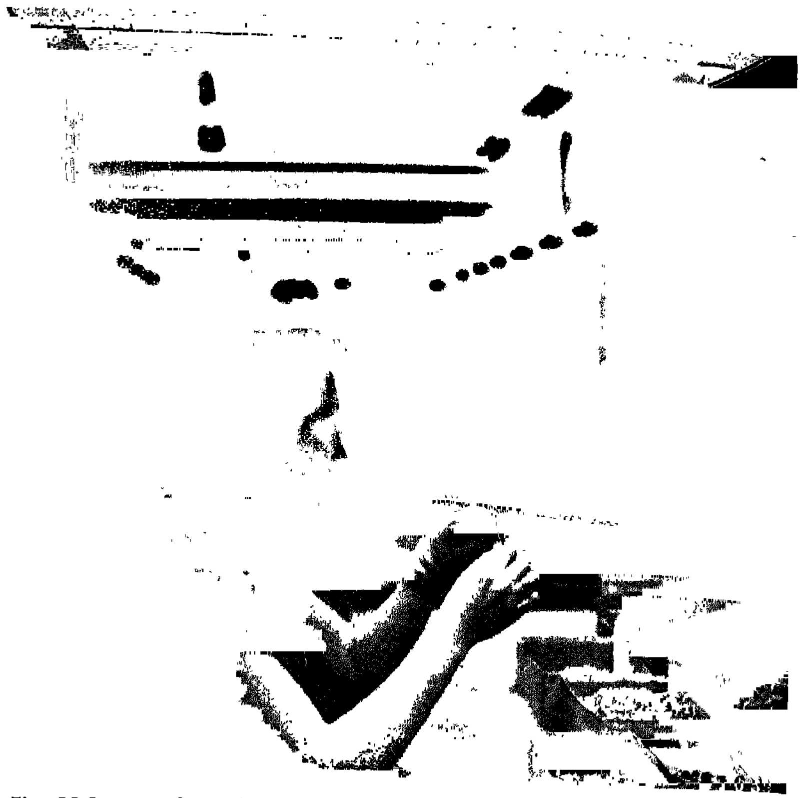


Fig. 12.2. Good Local Illumination. (Courtesy, The General Electric Co.)

factors should be taken into account, the more important being: (1) the proper type of illumination, (2) the correct kind of lighting unit, (3) the effect of glare, (4) the proper intensity, (5) the distribution of light, (6) the quality of the light, (7) the type of light source, and (8) the physical characteristics of the room.

TYPES OF ARTIFICIAL ILLUMINATION

The principal types of illumination are: (1) general, (2) local, and (3) a modification of these. General illumination has to do with the uniform distribution of light over the whole department in a sufficient intensity to satisfy the requirements of the general manufacturing conditions within it. This is accomplished by spacing lamps of the proper wattage equidistant from one another. The spacing depends on the distance between the floor and the bottom of the globe or reflector of the lighting unit, or luminaire. This distance is called the mounting height. The spacing varies, usually, from 0.8 to 1.2 times the mounting height, depending on the type of luminaire.[4]

[4] *The Westinghouse Lighting Handbook*, Westinghouse Electric Corp., Bloomfield, N. J., pp. 6-8 to 6-23.

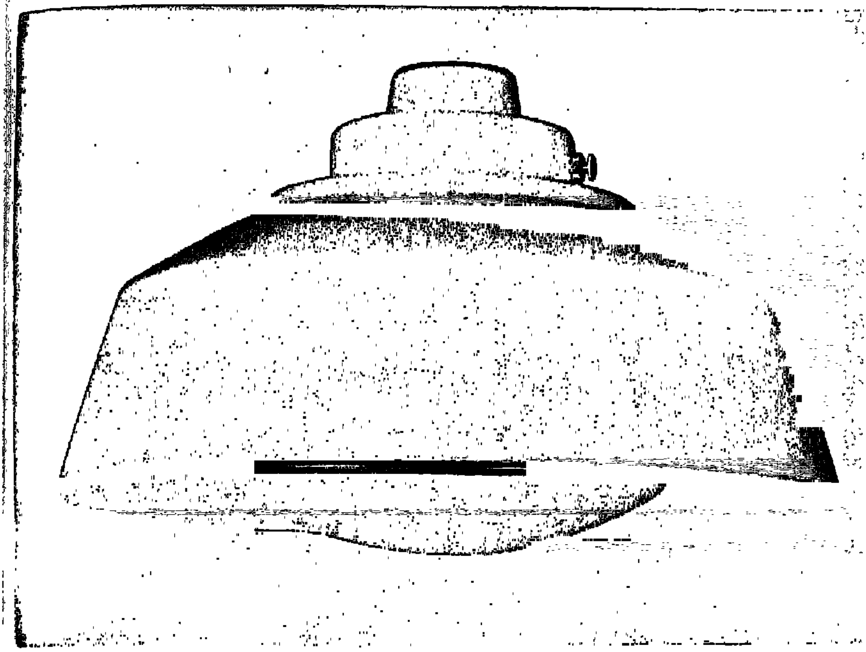


Fig. 12.3. Standard Dome Reflector with Glass Diffusing Bowl. (Courtesy, Westinghouse Electric & Mfg. Co.)

Local illumination involves the provision of a more intense light at the point of work or for areas adjacent thereto (Fig. 12.2). Such light should supplement the general lighting of the department, for reasons that will be apparent shortly.

In some cases, one group of machines may require a higher intensity of light than that needed for other machines, and the general lighting scheme must be modified to provide this intensity. This is known as group lighting.

THE TYPE OF LUMINAIRE

Lighting systems may be grouped into five classes: (1) direct, (2) semi-direct, (3) general diffuse, (4) semi-indirect, and (5) indirect.[5] The type of luminaire is determined by the type of lighting system to be employed. Direct lighting, the usual form found in shops, may be defined as any system in which substantially 90 to 100 percent of the light is directed downward from the light source by the luminaire, and falls directly on the working surface. In most instances, the lighting unit consists of a light source mounted in a dished and enameled metal reflector. The R.L.M. standard dome reflector is widely used for the general illumination of

[5] *Ibid.*, pp. 4-6 to 4-8.

industrial interiors. Where smoke or dust is prevalent, it may be equipped with a dust-tight glass cover. When more than 12 foot-candles intensity is required, the standard reflector with a glass diffusing bowl shown in Fig. 12.3 is desirable. By slotting the reflector to permit a small proportion of the light to go to the ceiling, sharp contrasts between a brightly lighted working plane and a dark ceiling are avoided. In ordinary industrial concerns, such luminaires may be mounted at heights ranging from 9 to 12 feet. The mounting heights may be greater if necessary, but this is undesirable. High-mounting reflectors must be used above 20 feet; these are designed to concentrate the light from a considerable elevation on the plane of work. Their use is required with the cranes shown in Fig. 11.5 for obviously the lights must be mounted above the cranes. Such lighting may be supplemented by light from symmetrical or elliptical angle luminaires. When the mounting height is less than 8 feet, deep-bowl reflectors must be used. Luminaires of the kind shown in Fig. 12.2 are frequently used for local lighting.

Semidirect lighting includes any system in which 60 to 90 percent of the light falls directly from the source on the working surface, but a substantial proportion is directed by the luminaire to the ceilings and side walls from which it is received by reflection. General diffuse lighting directs 40 to 60 percent of the light from the luminaire downward at angles below the horizontal. Semi-indirect lighting is any system in which 60 to 90 percent of the light is directed by the luminaire to the ceilings and side walls, from which it is received by reflection, but a substantial proportion falls directly from the light source on to the working surface. The light bulb is often housed in a semiopaque glass bowl. These lighting systems are less efficient than direct lighting, in so far as the cost of light production is concerned, but the light is softer and better diffused. Much of the light is absorbed by the reflecting surfaces in the luminaire, its glass diffusing bowl, the ceiling and side walls. Such luminaires are used commonly in offices, and occasionally in shops that require maximum freedom from shadows in producing a fine, high quality of work.

Indirect lighting is any system in which 90 to 100 percent of the light is directed upward by the luminaire to the ceiling and side walls, and transmitted from those surfaces to the plane of work by reflection. The light source is housed in opaque reflecting bowls. From the standpoint of cost, indirect luminaires are the least efficient light producers. Their maintenance cost is greater, and unless they are cleaned frequently, the accumulation of dirt seriously reduces their efficiency. They produce a soft, highly diffused light, however, that gives the room a pleasing appearance. They

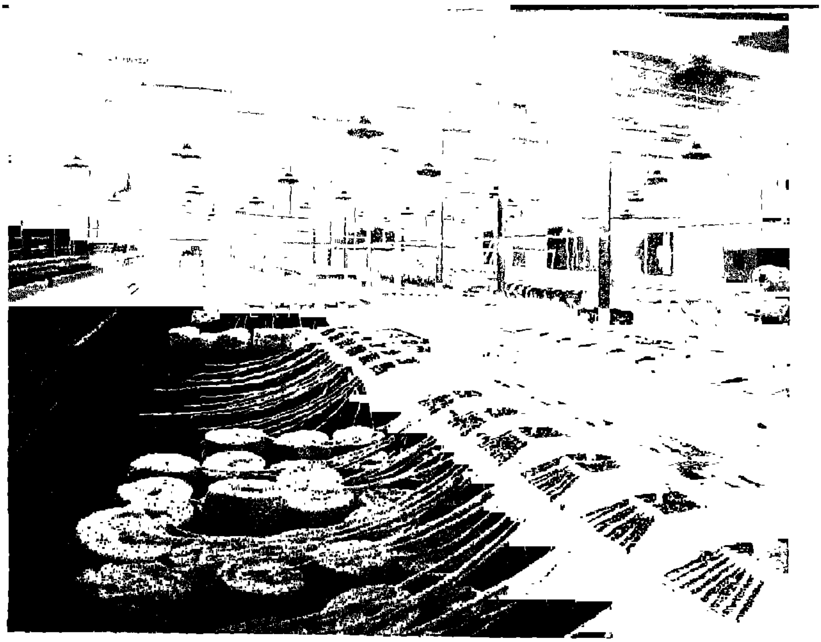


Fig. 12.4. Before Installation of Modern Lighting System in a Textile Mill. (Courtesy, Westinghouse Electric & Mfg. Co.)

Fig. 12.5. After Installation of Modern Lighting System in a Textile Mill. (Courtesy, Westinghouse Electric & Mfg. Co.)

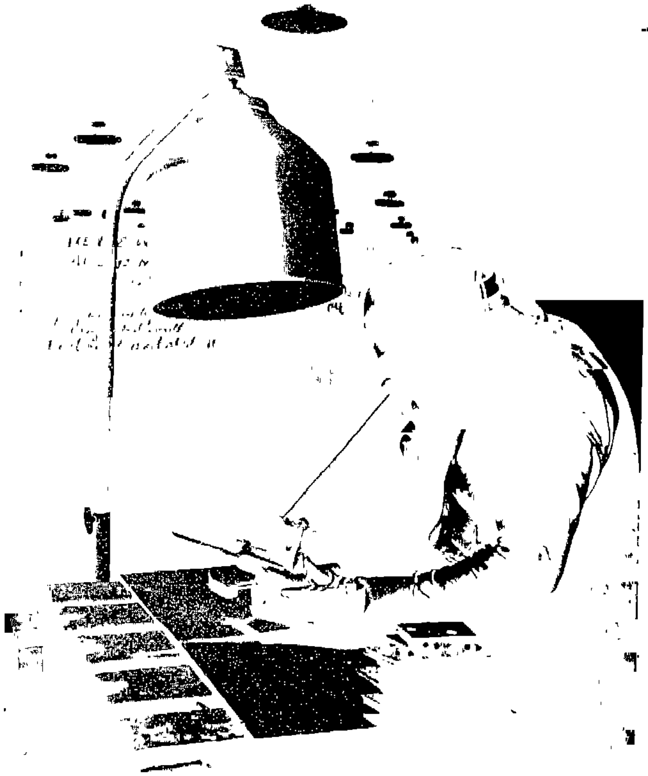


Fig. 12.6. Glare Resulting from Poor Local Illumination. (Courtesy, The General Electric Co.)

are used in industry chiefly in general offices or other places where the public or representatives of other organizations have access.

GLARE AND ITS EFFECTS

Glare has been defined as a condition of brightness within the field of vision that causes discomfort, interference with vision, or eye fatigue. It may be caused by sharply contrasting areas of brightness and darkness, because the eye has difficulty in adjusting itself to such contrasts. The interior of the textile mill shown in Fig. 12.4 is illuminated by standard enameled-dome luminaires hung from drop cords within a few feet of the plane of work. As a result, the brightly lighted work area contrasts sharply with the surrounding areas. This picture also illustrates another condition which is sometimes called "reflected glare." When a light-colored or highly polished material is being worked on, it may reflect light from the source directly into the operator's eyes. This condition is most unpleasant for the employee. It may make it almost impossible for

him to observe accurately the details of his work, particularly when he is working on polished metal surfaces. Figure 12.5 shows the interior of the same shop after a modern lighting system was installed.

Direct glare may result when a very brilliant source lies within the field of vision. Too few luminaires of too great brilliancy, spaced too far apart, is a common cause of direct glare. Local illumination by means of clear lamps hung on drop cords at the machine, shielded by improper reflectors, or entirely unshielded, is another cause. An example of glare is shown in Fig. 12.6. Direct and reflected glare may be reduced by adjusting the spacing and height of the lamps so that there is a wide angle between the eye, the work, and the source of light, by selecting the proper luminaires, and by using lamps of the proper wattage to give the correct intensity of illumination.

THE INTENSITY AND DISTRIBUTION OF LIGHT

The amount of light that should be produced depends largely on the factors noted above. Insufficient light tends to produce eyestrain and fatigue, and makes it difficult for the employee to work quickly and accurately. The proper intensity of illumination is a function of the type of manufacturing and the class of work, as shown by the following classification of intensities.[6]

Industry	*Operation*	*Maintained Foot-Candles*
Airplane manufacturing	Subassembly	30
Automobile manufacturing	Frame assembly	30
	Assembly line	100
Clay products	Grinding, filter presses, kiln rooms	5
	Molding, pressing, cleaning, and trimming	20
	Color and glazing	30
Foundries	Charging floor, tumbling, cleaning, pouring, and shakeout	10
	Molding and core making	50
Glass works	Mix and furnace rooms, pressing and lehrs, glass-blowing machines	10
	Fine grinding, polishing, beveling, etching, and decorating	50
	Inspection	100
Machine shops	Rough bench and machine work	20
	Medium bench and machine work, ordinary automatics, rough grinding, etc.	50

[6] *Ibid.*, pp. 5-3 to 5-14.

Industry	*Operation*	*Maintained Foot-Candles*
	Fine bench and machine work	100
	Extra fine bench and machine work	200
Shoe manufacturing	Cutting	20
	Marking, skiving, and sorting light materials	20
	Marking, skiving, and sorting dark materials	100
	Lasting and welting, light materials	20
Woolen textiles	Carding, picking, washing, combing	35
	Weaving light goods	40
	Weaving colored goods	80
Office	General, no close work	30
	Close work	50
	Drafting room	50

When more than 30 foot-candles intensity is required, it usually is best obtained by supplementing the general illumination with some form of local lighting. The present trend appears to be toward higher intensities than have been considered necessary in the past.

The correct distribution of light is also dependent on the basic factors discussed previously. Not only is it an important consideration in such problems as glare and correct intensity, but it enters into the problem of getting the light to the point where it is needed. Note has been taken previously of the use of deep-bowl reflectors, side mountings which use angle reflectors, floodlights, etc.

THE QUALITY OF LIGHT AND THE TYPE OF LIGHT SOURCE

In some cases, the color of the light may be important. Thus special lights (daylight lamps) have been developed for department stores and industries that have to match colors closely. In drafting rooms and other places where the work is fine and must be accurate, the light should minimize or eliminate shadows. An important factor in this problem, of course, is the distribution and diffusion of light. Its quality is also a factor, as we shall see shortly.

It is evident that the quality of light and the type of light source are closely related. The principal light sources used in industry today are the mercury vapor light, the fluorescent light, and the incandescent light. Mercury vapor lamps are shown in Fig. 10.3. Light is produced by passing an electric arc through mercury vapor in a long glass tube housed in a troughlike reflector. Its advantage is that it does not produce sharp

shadows. This light has a bluish-green color. It gives the workers and their surroundings a most unnatural and unpleasant appearance, but it is not injurious. Men become accustomed to it and work under it for years. A high-intensity mercury lamp has been developed that largely overcomes these objections. It produces a pleasing blue-white light. It contains no red light, however, and hence cannot be used where color discrimination is necessary. Combinations of high-intensity mercury lamps and incandescent lamps have been used to get a light that closely approximates daylight in quality. The lights shown in Fig. 12.5 are fluorescent lamps mounted in industrial trough reflectors. Installations of incandescent lamps are quite satisfactory for most purposes, when properly designed.

THE PHYSICAL CHARACTERISTICS OF THE ROOM

The physical characteristics of the room have an important influence on the design of lighting installations. The three most important factors are: (1) the general proportions of the room, (2) the color and condition of the walls and ceilings, and (3) the condition of the air in the room. The room proportions affect the spacing of the lights, their mounting heights, and the amount of light that will be reflected. (It has been pointed out previously that much of the light that reaches the plane of work is reflected.) The amount of light that is absorbed depends on the kind, color, and condition of the reflecting surface.

The effect of color is shown by the following table.[7]

Color of Reflecting Surface	*Percentage of Light Reflected*
White	85
Cream	75
Bright yellow	65
Light blue	48
Olive green	40
Light russet	30
Blue	21
Deep red	14
Brown	9
Deep blue	7
Dark green	7

Some manufacturing processes throw off considerable quantities of dust, smoke, soot, or fumes, which may absorb much of the light. Luminaires quickly become dirty; this reduces their lighting efficiency, and in addi-

[7] *Illumination Design Data*, appendix: "Reflection Factors of Various Colored Paints," Lamp Division, General Electric Co.

tion makes the cost of maintaining them in good condition correspondingly high. Special luminaires may be required to resist corrosion. Such conditions must be taken into account in analyzing the lighting situation. The analyst usually classifies them as very good or fair, depending on his observation and judgment.

THE ANALYSIS OF LIGHTING CONDITIONS

The large lamp manufacturing companies have prepared pamphlets which explain in simple terms the principal phases of the industrial lighting problem. They have also developed simple methods of analyzing lighting requirements of typical manufacturing conditions.[8] The first step usually is the determination of the kinds and types of work in the area to be lighted. The proper number of foot-candles may then be found by referring to the illumination tables for these particular conditions. The actual intensities may be checked at various points in the shop by means of a portable instrument known as a foot-candle meter. The type of luminaire must next be considered on the basis of the factors discussed above. The lighting conditions are evaluated qualitatively, as favorable, average, or unfavorable, by reference to other tables dealing with room proportions, the color of the reflecting surfaces, and the maintenance problem. The layout of the outlets is then checked. The mounting heights of the luminaires in the average industrial plant should be from 9 to 12 feet above the floor, and the outlets should be spaced uniformly, as noted previously. The distance between them should be equal to or slightly greater than the mounting height. The area of illumination per outlet is found by dividing the total room area by the number of outlets. With these data, the determination of whether a 200-watt or a 500-watt lamp or some other should be used in each outlet is merely a matter of referring to other tables. Finally, the capacity of the wiring system should be checked to make certain that it can carry any increase in load that may be necessary.

The subject of illumination has been presented in some detail to make clear the nature of the information that the line executive should have to make policy decisions concerning technical plans. This knowledge does not enable him to dispense with the services of a technical specialist in difficult problems, any more than a general knowledge of business law makes the services of a lawyer unnecessary. The knowledge and understanding of technical problems that are required by a general executive may be obtained without great difficulty. Its comprehension requires no highly specialized background and training.

[8] *The Westinghouse Lighting Handbook* and *Bulletin LS 119* of the General Electric Company's Lamp Division are examples of this information.

Air Conditioning

Air conditioning may be defined as the control of the relationships between certain characteristics of the air, such as temperature, purity, humidity, movement, and distribution, to the end that the air will meet the requirements of a particular situation in a room or building. The sharply upward trend of new orders received by manufacturers of air conditioning equipment is a good index of the increasing importance that management is attaching to the problem.

The installation of a complete air conditioning system always involves considerable investigation and study by the management, relatively heavy investment by the owners of the business, and continuing cost for operation and maintenance. The system must produce sufficient values to warrant these expenditures. As a rule, the most important objectives of management in taking this step are: (1) better health for employees, (2) removal of unpleasant odors, (3) greater *per capita* production, (4) better quality of product, (5) minimum deterioration of materials in storage, (6) reduced maintenance charges, and (7) better morale.

In many ways, the temperature, humidity, and purity of the air are factors in the health and comfort of the employee. Any production manager will testify that a bad epidemic of colds in a department lowers production seriously as a result of both absenteeism and a temoprary reduction in the productive capacity of employees. Not only is this costly to the organization, but it may mean a serious expense to the employee in the form of doctors' bills and lost earnings. During the first year after the Philadelphia Electric Company installed a complete air conditioning system on the main floor of its head office, the time lost because of respiratory disorders decreased 33 percent; during the second year, the decrease was 46 percent. This experience has been repeated in other departments of this company, as well as in other companies.

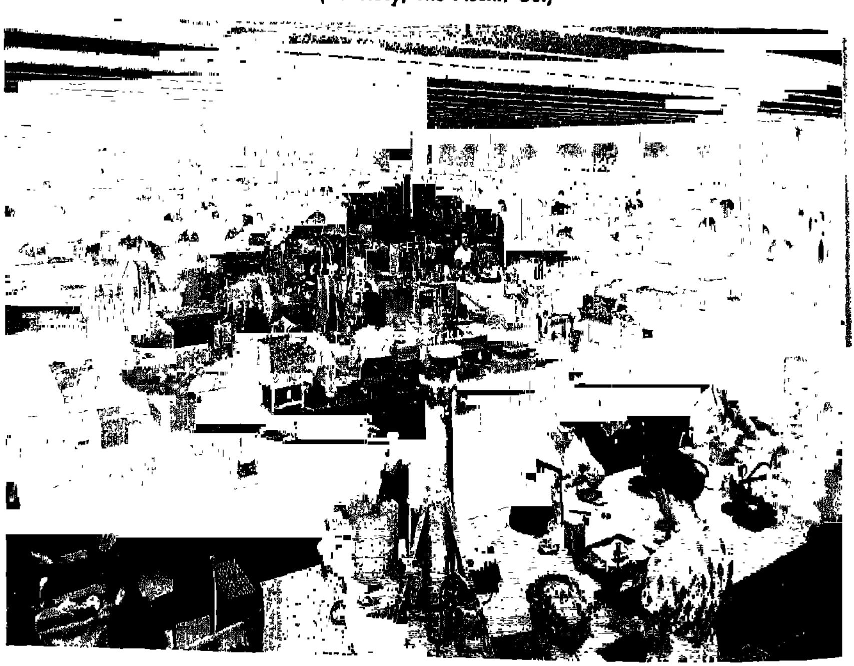
Certain types of manufacturing operations impregnate the air with injurious fumes or foreign matter. For example, employees in grinding rooms often wear gas masks to prevent the fine, gritty materials in the air from entering their lungs; furthermore, the grinding wheels are usually equipped with exhaust hoods. When many people are congregated in a relatively small enclosed space, the air soon becomes vitiated and acquires an unpleasant odor unless it is changed frequently.

Air conditioning may also affect greatly the quantity and quality of production. There is a definite relation between the employee's comfort and productivity on the one hand, and temperature and relative humidity

on the other. As the temperature approaches 80° Fahrenheit, it becomes increasingly difficult to maintain conditions under which people can work with maximum effectiveness. The ease and speed of processing materials in the textile industry are dependent on the maintenance of certain conditions of the air. Air conditioning enables southern manufacturers to provide a northern climate in their plants in summer. Figure 12.7 shows an air-conditioned work area for the assembly, testing, and inspection of electrical products. The ceilings are covered with acoustical tile. A high level of artificial illumination is supplied. In many other industries, such as foodstuffs, candy, drugs, and chemicals, air conditioning has increased the ease of processing, decreased costs, and improved quality. In some cases it has enabled manufacturers to regularize the production of goods that are subject to rapid deterioration with changes in weather. Thus in the meat-packing industry, air conditioning aids the packers in handling livestock offerings; the meat is put in storage within a relatively short time after it is shipped to the market.

Air conditioning can effect economy in manufacturing in many other ways. For example, the corrosive fumes or excessive moisture thrown off

Fig. 12.7. Good Working Conditions in the Sangamo Electric Company's Plant. (Courtesy, The Austin Co.)



by some processes may be injurious to the machinery as well as to the employees. Failure to correct these conditions may greatly increase maintenance charges.

It is evident that the installation of air conditioning tends to advance the interests of both the organization and the individuals who compose it. It should be backed up by adequate educational activities, however, if the company is to obtain the improved morale which should result.

The problem of air conditioning varies with the seasons. In winter it is necessary to heat and humidify the air, whereas in summer the usual problem is to cool and dehumidify it properly. Again, clean, pure air may have to be supplied if the natural ventilation is inadequate. An efficient air conditioning system must be able to control the important characteristics of air at every season of the year under all conditions.

The characteristics of the building greatly affect the efficiency of the air-conditioning system. Considerable air usually leaks around the window frames and other apertures. In spring and summer when the weather is pleasant, the employees may open the windows without realizing the effect on the air-conditioning system. No air-conditioning equipment can function satisfactorily in the face of outside weather conditions. A few concerns have built windowless buildings with doors that can be sealed, in order to supply the employees with as nearly perfect light, heat, and ventilation as possible.

THE CONTROL OF AIR CONDITIONS

Most manufacturing plants are heated by steam or hot water produced on the premises. Large plants may require so much steam for this purpose that it may be more economical to produce electric power than to purchase it. In such cases, exhaust steam from the engines or turbines may be used. Where there is no integrated system of air conditioning, unit heaters are being increasingly used instead of stands of iron pipes or banks of radiators. These unit heaters are usually suspended from the ceiling. These consist of a radiator through which hot air is drawn by a fan. Their advantage is rapidity of heating because they provide a large heating surface in a small space. Unit heaters can be located at strategic points throughout the room. These heaters can move the air more rapidly than convection currents do. The fact that they can be located almost anywhere gives them greater flexibility than the conventional heating units of the past. Heat production and distribution can be closely controlled by means of thermostats. Units heaters may be equipped with humidifiers, but the relation between temperature and humidity cannot be regulated accu-

rately. Although their installation costs are low, maintenance and operating costs may be high.

Humidity is a condition of air that is dependent on the proportion of water vapor in the air at any given time. The amount of water vapor that air will hold increases with temperature. When we use this term, we usually mean relative rather than absolute humidity. Relative humidity is the ratio of the actual weight of water in a cubic foot of air to the weight of water in an equal volume of saturated air at the same temperature. A simple device known as the wet-and-dry-bulb thermometer makes it possible to determine this ratio readily. The temperature for maximum human comfort and effectiveness varies inversely with the relative humidity. The exact relations vary between individuals, but in general they conform to those in the following table:

Temperature in Degrees Fahrenheit	*Relative Humidity*
65	80 per cent
68	60
70	45
72	30
74	20

According to this table, most of us will be just as comfortable at 68 degrees with 60 percent relative humidity as at 74 degrees with 20 percent humidity.

The production of a supply of pure air involves two problems, the cleansing of the air and the ventilation of the room or building. Air may be cleansed by passing it first through baffle plates and then through a fine spray in an enclosed chamber, which washes out most of the foreign matter. The air has a tendency to become saturated with moisture as it passes through the washer, but its relative humidity may be adjusted subsequently by running it through a drier, by raising its temperature, or by other means.

Ventilation has to do with the removal of air that has become vitiated, charged with fumes or unpleasant odors, etc., and the renewal of the supply of fresh air. Ventilators in single-story buildings may use air from windows in the faces of the sawtooth roofs or in the monitors; in multistory buildings, they may depend on the windows in the side walls. Some plants are equipped with roof ventilators. Exhaust fans are frequently used for general ventilation, as well as for ventilation in special processes that make the air impure. The disadvantage of such methods is that they are not integrated with the other elements of an air-conditioning system.

While these methods may aid in maintaining a fresh, pure supply of air, they make it difficult or impossible to control its temperature and humidity with sufficient accuracy.

In summer, the air-conditioning problem usually is to maintain the air in the room or building at a temperature and humidity lower than that of the outside air. Here air motion is a factor, the temperature of moving air for comfort being higher in summer and lower in winter than it is for still air. The movement of air affects the rate both of evaporation of perspiration from and of heat transfer to the body. However, the velocity of the air in the room should not be noticeable; it should not exceed 50 feet per minute. As we have noted above, the comfort level may be maintained by decreasing the relative humidity as the temperature increases. In summer the temperature in the building should be kept above 68° Fahrenheit to avoid too great a contrast with the outside air. Customers leaving an air-conditioned department store often experience great discomfort if the temperature differential between the store and the street is too great.

For best results, the various devices for conditioning the characteristics of the air should be integrated into a complete system. In such a system, the necessary volume of fresh air is drawn in from the outside by means of a fan. The volume varies, of course, with circumstances; but in most cases from 2000 to 3000 cubic feet of air per person is required. The air is then passed around baffle plates to remove the heavier matter. From here it passes through a washer which further cleanses and humidifies it, and it then goes through a drier which provides the moisture content proper for the desired temperature. Next it passes over heating or cooling coils which give it the desired temperature. The conditioned air is then piped to outlets located at strategic points throughout the building, and is discharged at the proper velocity. Circulation is maintained by drawing off and discharging air to the outside at the same rate that it is taken in. With such a system, the temperature and humidity of the air may be controlled accurately by means of thermostats and humidistats, and its purity is assured.

While it is not difficult to gain an understanding of the objectives, general principles, and methods of air conditioning, the solution of specific problems frequently raises some intricate difficulties. They require a technical knowledge that is usually not found in the average manufacturing concern. It is necessary to rely on and work closely with the engineers of reliable manufacturers of air-conditioning equipment.

The Significance of Physical Factors in Factory Operation

It was pointed out in discussing the fundamentals of organization and operation, that the proper performance of any business functions necessarily depends upon the presence of certain physical factors of condition. It was noted, in connection with standardization, that there is usually a single best state and interrelationship for these factors for maximum results in a specific situation. Therefore the determination and use of the best criteria of condition improves the quality of work, increases the magnitude of results, and reduces the cost of operations, at least in some degree. It is the function of capital to provide the organization with suitable physical factors in performance. It is a function of management to assure the presence of these physical factors when needed, and in the kind, degree, and quantity required. Management must also assume the responsibility for properly planning, organizing, and controlling their use in the achievement of the company's service objectives. As these and other concepts suggest, the practical solutions of such physical problems as plant location, the factory building, manufacturing equipment and its layout, etc., rest directly on the philosophy of management that was presented earlier in the text.

CHAPTER 13 •

• Plant Engineering and Maintenance

The Objectives of Plant Engineering and Maintenance

PLANT engineering and maintenance is a technical staff function. Its work has to do largely with the provision of plant, and with the maintenance of capital equipment. This function involves the provision and maintenance of good physical working conditions. It therefore may include the operation of certain services that are associated closely with these functions and factors. The importance of the maintenance function has increased greatly, since the beginning of World War II, because of the greater rate of industrial mechanization. This is particularly true in large continuous assembly industries that have developed automation. The staff-to-line ratio of maintenance personnel tends to increase, with continuing transfer of skill and knowledge from the line operative to the machine.[1] It tends to increase also with the increasing size and power of production equipment. An examination of the objectives of the plant engineering division is desirable, in view of the tendency of its expense ratio to increase.

There is a "Gresham's law" of standards. It states in effect that the bad standards in an organization tend to drive out the good. It becomes difficult and sometimes uneconomical to maintain and apply certain standards when other related standards have been allowed to deteriorate. The expense of developing standards of condition, such as those noted previously, is hardly worth while unless the company expects to maintain the various physical factors in the condition specified by those standards.

[1] The extent to which mechanization is practicable is a function of volume of business and organization size, as well as the degree of standardization of product and process. Some support for this contention is found in the increasing ratio of staff operatives to line operatives with increasing organization size. See A. W. Baker, and Ralph C. Davis, *Ratios of Staff Employees and Stages of Differentiation of Staff Functions*, Research Monograph 72, Bureau of Business Research, Ohio State University, p. 21.

Considerable economies and increases in efficiency usually follow the proper organization and control of maintenance work. In small plants, for example, this work is often in the hands of a maintenance foreman, who is a good mechanic rather than an executive. When he is notified by a department foreman that a machine has broken down, he sends a mechanic to that department as soon as one is available. The mechanic probably will return to the maintenance shop when he has decided what tools will be needed for the job. While he is making the necessary repairs, the production of the machine is lost, the overhead which this production should absorb must be charged elsewhere, and the operative's wages for the time lost will probably have to be charged against an overhead expense account for his department. Moreover, the cost of the repairs is usually greater than it would have been had the breakdown been anticipated. There are many other wastes that may result from poor maintenance. This brief discussion merely indicates some of the values that constitute the objectives of good plant engineering and maintenance. The principal objectives are: (1) a condition of plant and equipment that will satisfy the requirements of economical production, as specified by the standards of production; (2) continuous machine operation, in so far as this depends on a minimum number of machine breakdowns; (3) a minimum loss of time and production when such failures occur; (4) minimum maintenance and repair costs, and (5) such plant services as may be needed.

The Plant Engineering and Maintenance Organization

Much of the work of plant engineering and maintenance may be done, in very small concerns, by members of the shop department, working under the direction of the foreman. Work that cannot be handled in this manner is usually done by outside jobbing machine repair shops or other service agencies. Under these conditions, plant functions are integrated with the department's primary operative functions.

The specific structure of a staff organization depends on the stage to which it is economical to carry the development of the particular staff function. The conditions of staff differentiation were discussed in Chapter 4. The organization shown in Fig. 13.1 merely suggests the principal groups of functions that may be placed under the general direction of the plant engineer. These functions are plant maintenance, maintenance inspection, plant service, plant construction, power production and distribution, and office and records. They will be discussed shortly.

The head of the organization, in Fig. 13.1, has been given the title of plant engineer. He may be known as the maintenance superintendent in small concerns. The plant construction and power production functions may not be developed in such concerns. He is responsible in any event for:

1. Prompt emergency repairs.
2. Periodic inspections of buildings, machinery, power lines, and other equipment.
3. Routine repairs and adjustments, as a result of such periodic inspections.
4. Planning such modifications and extensions of plant buildings as may be necessary to accommodate current manufacturing plans and provide suitable space for business growth.

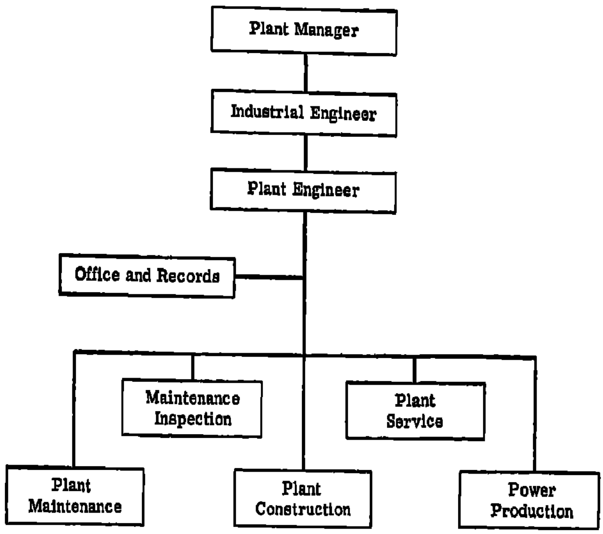


Fig. 13.1. The Plant Engineering and Maintenance Organization

5. The production and distribution of light, heat, and power, as required.
6. The operation of such service departments as may be assigned to him.
7. The maintenance of such records and the origination of such reports as may be necessary for accounting, as well as other management purposes.
8. Effective, economical management of the plant engineering functions that are under his command.

The plant engineer reports to the chief industrial engineer, in Fig. 13.1, because of certain basic similarities between plant engineering and maintenance, and other staff process planning functions that have been noted previously.

The Maintenance Organization and the Limitation of Staff Economy

A staff organization may be affected greatly by the limitation of its operating economy that is necessitated by the requirements of normal line-staff relationships. This limitation may be stated as a principle as follows: In order that the primary functions may be performed with maximum economy and effectiveness, the related secondary functions must usually be performed with less than maximum economy and effectiveness. Primary functions are those managerial and operative functions whose performance results directly in the creation of primary service values. These are salable values for the most part in business organizations. Any staff function necessarily is a secondary function. So far as staff organization structure is concerned, the usual effect of this limitation is to make necessary some overorganization relative to the volume of work to be handled.

The maintenance organization is an example of the operation of this principle. In most concerns, there are times when maintenance operatives have hardly enough work to keep themselves busy; but at other times they may have to work overtime. Production equipment seldom considers their convenience in breaking down. As a rule, the company's ability to pay wages, give prompt service to its customers, and earn a return on its investment depends on the continuous efficient operation of its primary equipment. A machine which has broken down must be returned to production as quickly as possible. The size of the maintenance department more nearly approximates the man power necessary to handle the peak load of maintenance work that may reasonably be anticipated, rather than the average load over a period of time. It is unwise, furthermore, to lay off workers during dull times because of the specialized training and experience needed for this work. It is usually impossible to spread the load of emergency repair work over a period of time. This creates other problems in regularizing the work. The problem of control is made difficult because the line organization must be given prompt service in emergencies.

The Maintenance Function

The maintenance department operates various mechanical shops. These shops repair production machinery, power transmission equipment in the plant, conveyors, and other equipment. They maintain water, air, steam, and gas lines. The electrical shops may rewind motors, make repairs on lighting equipment, and handle other electrical jobs in or around the plant.

Millwrights install new machinery, move machines to new locations and set them up when the plant layout is changed. The maintenance department handles many other jobs of a similar nature. Figures 13.2 and 13.3 will aid the reader in visualizing the general nature of the work. Because of the varied nature of the work, the maintenance department must employ many kinds of mechanics, such as plumbers, steamfitters, millwrights, carpenters, machinists, and electricians. The department may be organized in large concerns into smaller units such as the pipe shop, carpenter shop, electrical shop, etc. In the small plant the maintenance shop may be composed of only one or two general mechanics.

The equipment of the maintenance shops usually consists of general-purpose machine tools used by the different trades, and small tools that are not normally a part of the mechanic's personal equipment. The de-

Fig. 13.2. A Maintenance Crew Making Emergency Repairs, Using a High-Lift Telescopic Platform Truck. (Courtesy, The Clark Equipment Co.)

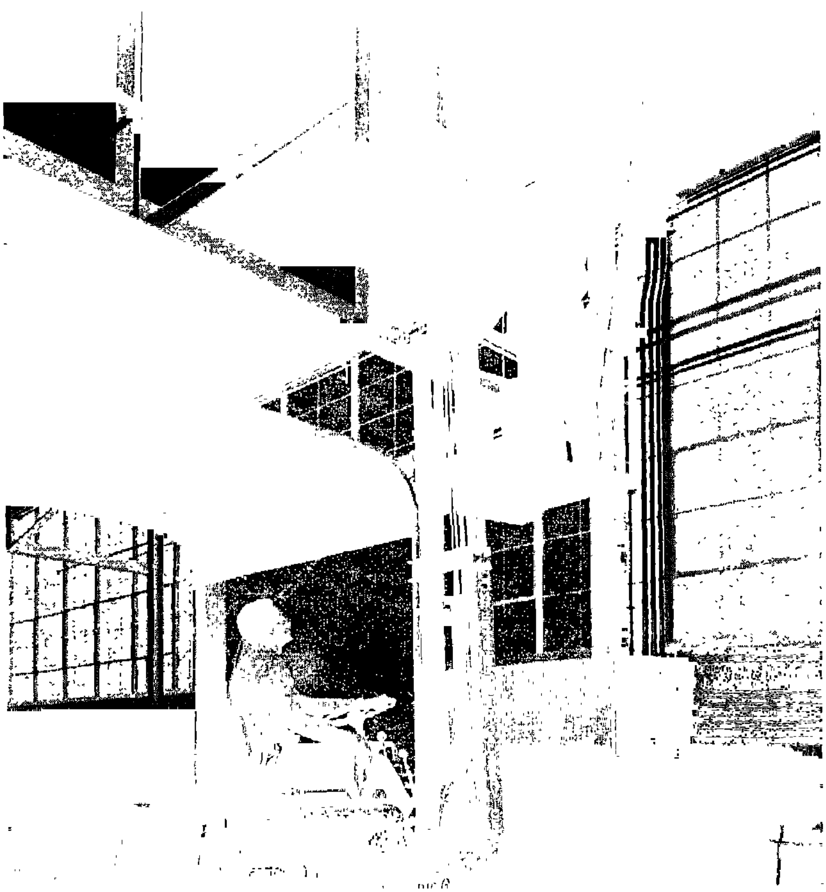


Fig. 13.3. Maintenance Men Tightening the Belt of a Live-Roll Conveyor by Means of a Portable Chain Hoist. (Courtesy, Yale & Towne Mfg. Co.)

partment must have its own tool crib to service these tools. Many necessary materials and supplies are peculair to maintenance work. These are often used in considerable quantities, and represent large expenditures of money. In consequence, the maintenance department may have its own storeroom, both for convenience and for closer control of these materials.

The rank of the head of the maintenance shops may range from foreman to superintendent, depending on the size of the concern and the type of manufacturing. His supervisory problems are quite as difficult as those of a production executive. For one thing, maintenance mechanics do much of their work at a considerable distance from the maintenance shop. This group, furthermore, is often less homogeneous than the personnel of the production shop.

Emergency Repairs and Their Control

Emergency repairs may be necessary because of any interruptions in production due to the failure of machinery and equipment to function properly in service. The cause of such interruptions must be removed and the equipment returned to production at the earliest possible moment. While emergency repairs may be reduced greatly in number through

maintenance inspection, they are always an important problem of the maintenance shop. The control of emergency repairs is difficult. In addition to the emergency nature of the work, these repairs must often be made on the machine at its location. This may be at some distance from the maintenance shop. There is, in consequence, a problem of remote control.

The production shop foreman usually notifies the maintenance office by telephone when there is an interruption of production due to a machine failure. He may also notify the production control office when it is evident that an order on the machine will become a back order. The nature and cause of the interference is usually shown, in addition, on the daily or weekly back-order report to production control from the department. It is the responsibility of production control to classify and analyze production interferences. These may be caused by many difficulties, in addition to machine failures. Information concerning production interferences is necessary, since it may be necessary to change production schedules.

The maintenance office should note the machine number, location, apparent cause of the break, etc., on an expense order blank.[2] The release of this order initiates action on the particular emergency project. We shall examine a typical maintenance procedure which represents good control, chiefly in order to show that it provides for the performance of all organic control functions in accordance with the principles discussed above.

If the interruption is a major one, such as the breakdown of a large machine whose repair will take considerable time and money, the maintenance office will probably call the maintenance inspector nearest the machine by means of an automatic call system. When he telephones in answer to his call, the office will ask him to look over the job and decide what repairs are necessary, how they should be made, what tools and equipment will be needed, and how long approximately the job should take. He will probably transmit this information by telephone, telautograph, or any other fast communcation system that is provided. The maintenance office notes this information on the expense order for the job. It is evident that this constitutes what may be regarded as the routine planning phase in the control of maintenance work; it seldom involves any original

[2] An expense order, when sign properly, authorizes expenditures that cannot be charged directly against primary production and do not increase the asset value of the business. The information on the order, together with accompanying instructions, should be sufficient to assure proper execution of the order, and expense charges by the accounting department to the proper account. These charges, in the case of machine breakdowns, are against the machine repair account of the production department involved.

decisions. When the chief clerk signs the maintenance superintendent's name on the expense order, if he has that authority, it becomes an order for the work. The original copy is usually sent to the cost department because the time and materials needed on a major repair may be considerable, and their cost must be collected. The second copy will probably go to the maintenance shop foreman as authorization for him to do the work in accordance with instructions. A third copy may be kept in the maintenance office for control purposes, and a fourth may be sent later to the production control office to notify it of the completion of repairs.

When the expense order is received in the maintenance shop, the foreman will assign the job to the first competent mechanic who is available. Inasmuch as it is an emergency, it takes precedence over any routine repairs that the man may be making. The foreman may use a planning board similar to that in Fig 16.12 except that it provides for the assignment of jobs to men rather than to machines. In this case he hangs the ticket for the emergency job on the top set of hooks, displacing the current job on which the man is engaged. In case all the available men are tied up with equally important work, the emergency job may have to be scheduled for the night crew, or other expedient action may be necessary. In large maintenance shops, such as railroad repair shops, the work of routine planning and scheduling is often highly developed. If the mechanic who is to do the job is out in the plant, the maintenance foreman locates him by telecall or some other fast means. He gives him the necessary instructions over the telephone, including the time estimate if one has been made. The job ticket for the mechanic's present job will be clocked out at the time of transfer, and the emergency job clocked in without necessitating his return to the shop. Thus the labor cost of the job can be collected, and a basis provided for determining the mechanic's efficiency. In the meantime, the materials and special tools required for the order should have been forwarded to the job, thus eliminating considerable delay. At this point, routine planning, scheduling, preparation, dispatching, and direction have been performed in some degree.

A maintenance inspector will check up on an important job to make sure that it is progressing satisfactorily. It is sometimes necessary to give a promise date to the production division so that its executives may know approximately when the machine will be available. This involves an estimate of how much work remains to be done, and how long it is likely to take. However, when the machine is torn down, additional work that

the original inspector could not anticipate is frequently brought to light. This must be reported immediately, so that the most expedient action may be taken. Additional time must be allowed, if the additional work is extensive. When the job is finished, a maintenance inspector checks it before it is released to the production division. The mechanic's job ticket is clocked out. The expense order is returned to the maintenance office. This office closes out the job with the cost and production control departments, and on its own records, usually by means of copies of the expense order. The maintenance office should get a report of the cost of the job from the cost department. This should be entered on the maintenance record for the machine. While considerable detail has been omitted in this description, it should be evident that all the organic control functions, including supervision, comparison, and corrective action, have been performed, and that a definite closure of the project has been made.

When the economics of control was examined, it was noted that an emergency situation might require a temporary centralization of control in some degree, but that a geographic dispersion of activities usually required its decentralization. It is evident that maintenance work requires rather highly centralized control within the maintenance organization, but that the maintenance mechanic is largely on his own after he goes out on the job. It has been noted also that the degree of centralization that is effective tends to vary directly with the speed, capacity, and accuracy of communication methods. In the modern maintenance department, the telephone, telautograph, or some type of industrial loud-speaker is in constant use. The amount of personal direction and supervision on a particular job that can be given to the mechanic by his foreman tends to be a minimum, nevertheless. Superior and subordinate may be separated by physical distances that preclude much face-to-face leadership. It is necessary, under such circumstances, that the mechanic be given thorough indoctrination and training in maintenance policy and procedure, since he must act frequently on his own initiative. This case presents other interesting problems in remote control.

It has been assumed, in the above discussion, that an important piece of equipment must be repaired at its location in the plant, when it has a major breakdown. But this is sometimes impossible. In some plants, if the breakdown cannot be repaired quickly, the machine is brought to the maintenance shop, and another machine is immediately set up in its place. Production proceeds with a minimum of delay. This procedure is profitable only in large plants that can make the necessary additional

capital expenditures. One large concern engaged in continuous manufacturing gets the same result by deliberately introducing a certain amount of excess capacity into its production lines.

Costs are not collected for all repairs that are made. For example, to collect the expenses of making a minor adjustment on a machine might cost more than actually doing this job. The expense order for such minor recurring service merely authorizes a standard charge against the proper departmental expense account on the basis of a standing order. Certain control functions, such as preparation, are unnecessary. This does not constitute an exception to our theory of control. If a situation required no control, there would be no necessity for any of the organic control functions; but all of them must be performed in some degree in any situation that must be completely controlled.

Maintenance Inspection

Maintenance inspection is the function of determining the condition of a piece of equipment by comparing it with the standards of condition and performance that have been prescribed for it. In many cases, these standards are merely qualitative criteria gained from practical experience. The chief purpose of this type of inspection is twofold: (1) to provide information that will aid in preventing the breakdown of the equipment, and (2) to make sure that equipment which has been repaired is in good operating condition. The maintenance inspector, as we have seen, may render valuable assistance in routine planning for maintenance control.

The periodic inspection of equipment results in many economies. It reduces greatly the number of emergency repairs that must be handled, and accordingly the number of interferences with production. A machine which fails under power may be damaged seriously, and in addition may involve great hazards for employees. Routine repairs are much less expensive. Such repairs can be planned and scheduled with a view to regularizing the load of work. The hours of work for routine repairs are less irregular, although most of this work may have to be done during other than regular shift hours. It may be possible to handle the same volume of work with a smaller maintenance crew, by regularizing work.

Before maintenance inspection can be organized and controlled, the equipment must be classified on the basis of inspection requirements. Some items of machinery may have to be inspected daily. Others, such as workbenches, may not require even annual inspection. Because the frequency of inspection needed for the great variety of equipment in a

factory may range anywhere between these extremes, the maintenance office must usually have some means that will call to its attention the necessity for inspecting a given item. The large amount of equipment in a big plant makes it desirable to assign an inspector to a definite area. Some such procedure as the following may be used. A maintenance inspection order, like that in Fig. 13.4, is made out for each item to be inspected. These orders are assigned to the various inspectors in accord-

INSPECTION ORDER

Date ________________ *Department* ________________

Mach. Name ________________________________ *Mach. No.* ______

Inspector ________________________ *Location* ________________

Instructions: ____

____

____

Inspector's Report: ____

____

____

Action Taken: ____

____

____

Next Inspection: ________________________

Signed, ________________________

Approved, ________________________

Fig. 13.4. A Maintenance Inspection Order

ance with the areas that they normally patrol. Any necessary instructions concerning inspection are stated on the order. The inspector makes any minor adjustments that can be made easily and quickly at the machine, notes on the order any further adjustments or repairs that are necessary, together with any recommendations he may have concerning the work. The inspector returns the inspection order to the maintenance office. This office makes out an expense order covering the work, and puts it on the maintenance shop schedule as described previously. The date of the next inspection is determined on the basis of the frequency required. It is entered on the inspection order, which is then filed in a chronological or tickler file against this date. When the next inspection is due, this

file automatically brings the old inspection order to the attention of the office, and with it the record of the last inspection. While this procedure has been simplified, it shows the principal factors and functions in maintenance inspection, and the relationships that should exist between them.

Plant Construction

The plant construction section makes all building repairs, as well as minor alterations and extensions. If there is much of this work, it may have its own crew of building mechanics. Otherwise, it will probably draw on the maintenance shop for whatever help it may require. As a rule, it does not handle new construction. Such work is done by consulting architectural and engineering firms. Only very large concerns can afford to maintain regularly a staff of architects and structural engineers; small concerns which are unable to afford any construction service must rely entirely on outside contractors.

Plant Service

We have defined plant service as the function of maintaining the condition of the factory building itself in the state required for economical production or the comfort and well-being of the employees. It is concerned largely with good plant housekeeping. The plant service foreman or supervisor may be responsible for the janitor service, window washing, elevator service, painting, fire protection, etc. At first glance, this work may not appear important, but progressive plant executives insist on good plant housekeeping for many reasons. For example, it is difficult to develop orderly, efficient work habits in men who must work in unclean, disorderly shops. Such conditions are not conducive, furthermore, to good morale and satisfactory labor relations. The movement of work is slower in a disorderly shop, and in consequence the turnover of work in process may be lower. The clean windows and bright reflecting wall surfaces which good plant housekeeping assures make for better lighting conditions and better production.

The danger of accidents is also reduced. Responsibility for neat, orderly shop conditions must rest primarily on the line executives and operatives, because it depends largely on their use of the areas under their control. Plant service makes important contributions to the maintenance of these conditions, however.

The janitor service includes the floor sweepers and washroom attendants. It may also be responsible for the periodic cleaning of luminaires, and the

replacement of burned-out light bulbs. Window washing is a big job in the large plant. There may be thousands of square feet of glass to be kept clean. There may be crews of men who do nothing else, in consequence. They are sometimes paid on a piecework basis. A crew of painters, similarly, may be engaged continuously in keeping the interior surfaces of the plant painted, additional painters being hired when necessary because of new construction. This crew of painters does not include any operatives who spray-paint the concern's products, of course.

The plant service division may operate certain related services. For example, the elevator operators may be responsible to this section of the maintenance department. It is true that they supply a transportation service for men and materials that may be regarded as a form of internal transportation; but the elevator also is an integral part of the factory building.

Fire protection is extremely important. It reduces both the risk of loss by fire and the fire hazard for the employees. It may reduce fire insurance costs. This section of the maintenance department inspects regularly all fire equipment, such as sprinklers, fire hose, extinguishers, etc. Large plants frequently have fire chiefs and volunteer fire crews in the various departments or divisions. These crews are given fire drills periodically, on the company's time. A well-organized police force is usually necessary in large factories. It includes the gatemen, night watchmen, and any other employees who are concerned primarily with the protection of plant property against theft or destruction. This is not primarily a personnel service, and in the writer's opinion it should not be under the personnel department.

Power Production and Distribution

A manufacturing plant usually must generate some steam for heating purposes. It may find it necessary to generate steam for use in its manufacturing process. Small concerns usually buy electric power from a public utility company. Large manufacturing companies may find it economical to generate and distribute electric power within the plant, for lighting and the operation of equipment. It may be economical if the company has to generate large quantities of steam anyhow.

The power plant organization, if we have one, will be headed by an executive who may have the rank of superintendent. He must have practical power-plant operating experience. He may have some professional training in heat power and electrical engineering. It is probable that he will report to the plant engineer.

The Plant Engineer's Office

The plant engineer's office aids in coördinating the various maintenance services with the needs of the line organization. Thus it obviously performs a secondary coördinative staff function. It is under the immediate supervision of a chief clerk, an executive assistant, or someone with a similar title.

The maintenance office keeps whatever permanent records may be required, an important record being the machine maintenance record shown in Fig. 13.5. The maintenance superintendent is often called

MAINTENANCE RECORD

Mach. Name ______________________ *Mach. No.* ________

Description ______________________________________

Department ______________________ *Location* ________

Purchase Price ______________ *Depreciation Rate* ________

Equipment ______________________________________

Date	*Repairs*	*Amt.*	*Date*	*Repairs*	*Amt.*

Fig. 13.5. A Machine Maintenance Record

upon for his opinion on the desirability of scrapping old equipment, or the purchase of new equipment and the reliability of the service that can be expected from it. If a card or loose-leaf record has been kept for each machine in the plant, the information thus available often aids him greatly in making such decisions.

Standards for Maintenance Work

Because of the irregular nature of maintenance work, it is difficult to set production standards except for such routine work as window wash-

ing, sweeping and similar jobs. In recent years, however, time and motion study has been extended to types of work which were formerly thought incapable of being standardized. As a result, some concerns now have time standards for almost all types of maintenance jobs, and on many of them they are able to offer wage incentives to the men.

PROBLEMS

1. About a year ago a firm manufacturing carburetors for automobile and marine motors replaced a large number of standard-purpose machines with equipment featuring multihead operations. Each new machine replaced approximately 13 employees. Output was significantly increased. Prior to installation of the new equipment, maintenance procedure was as follows: When difficulty was experienced with a machine the foreman analyzed the trouble and sent a work order to the maintenance department. When the maintenance mechanic began repair work he often discovered further repair needs. The foreman then issued a corrected work order which was approved by the maintenance superintendent. Confusion had often resulted as a result of two work orders being submitted on one repair project. Repairs were usually delayed: the maintenance man was required by the maintenance superintendent to make a complete inspection of the machine before the superintendent would approve the new work order. Such a procedure was definitely time-consuming and costly. Alternative equipment was usually not available to finish work taken from machines that were down for repairs. Down time was extremely expensive, consequently.
   (a) Suggest a procedure for increasing the effectiveness of maintenance in the above situation.
   (b) What are the maintenance problems that may accompany increasing mechanization?
2. The principal steps in the maintenance inspection procedure in a certain concern are as follows: Each day, the copies of the last inspection reports for the items to be inspected are removed from the tickler file and sorted by departments and inspectors. The maintenance office makes out a new inspection report form for each item, noting thereon any recommendations on the previous report. These previous reports are then filed temporarily to serve as a check list on the current day's inspections. Each inspector receives his report forms when he reports for work in the morning; he inspects each piece of equipment called for on his report forms, and enters on them his recommendations for repairs or adjustments. At the end of his tour of inspection, he turns in his reports to the maintenance department office, which checks them against the file of previous reports to insure that all items have been inspected. When the report has been approved by the maintenance superintendent, the maintenance office writes an expense order for the recommended repairs, and sends one copy of it to the maintenance shop as an order to do the work. The report is then filed in the tickler file against the next date of inspection for the particular piece of equipment.

(a) Draw a routine chart for this procedure. Analyze it to determine what organic control function underlies the proper execution of each step.

(b) Certain control functions are apparently absent. Does this mean that they cannot be regarded as organic? If not, under what circumstances may they be necessary, at least to some extent?

(c) Do any steps in the procedure seem insufficiently or incompletely developed? Why? Have you any suggestions for the possible improvement of this procedure?

3. The maintenance system of the Payter Company had recently become highly centralized. Formerly maintenance men had been on call whenever a repair job was necessary, but no specific schedule of maintenance work was in effect. Time and cost estimates for repair jobs were roughly approximated.

Repairs are now authorized by a work order. This order is sent by the foreman to the plant engineer. The latter is responsible for a cost estimate made of the repair job. If estimated costs are less than $40, the plant engineer orders the maintenance foreman to proceed with repair work. If costs are estimated at more than $40, the work order must be approved by the plant superintendent. If, after an initial estimate of less than $40, a repair project appears to require charges of more than that amount, approval of the superintendent must still be secured. All repair items needed are issued by the stores department only upon presentation by the mechanic of a copy of an approved work order. Upon completion of the work, a copy of the work order, with labor and materials charges, is sent to the cost department. This procedure has worked out reasonably well in routine repair cases. The management has found that emergency repairs are made even more costly by delays in starting repairs, and by interruptions while approvals are being secured.

(a) Why is the new system unsatisfactory for controlling emergency repair work? What control principles have been violated?

(b) Suggest a maintenance control system that will accommodate emergency as well as routine repairs.

CHAPTER 14 •

• Motion and Time Study

Objectives in Determining Operative Production Standards

A STANDARD has been defined as that which is established by authority, custom, or general consent, as a model, criterion, or rule for measuring. The function of standardization is the determination of such criteria. Operative production standards are criteria of economy and effectiveness in the performance of operative functions. This function of determining production standards provides standards of conditions under which a given operation should be done, standards of procedure for the correct performance of the operation, and standards of performance by which to gauge results, in so far as a proper rate of production is concerned. Standards for primary operative functions are determined usually by a time-study department, using process analysis and motion-and-time-study methods. These are techniques for functional analysis. Such techniques are based on the scientific method of approach. Motion and time study is an extension of process planning into an individual operation, or step, in a particular process. It makes a thorough analysis of the operation, including working conditions, equipment, and other factors affecting its performance, to determine the correct method and time for performing it.

The determination of production standards will be discussed in some detail, because they affect the performance of a number of important managerial functions. The problem of determining a fair day's work, for example, involves two important considerations, the length of the work period and the rate of production. Motion and time study deals with the latter. Such study involves fundamentally an attempt to arrive at a practical basis for integrating the employee's personal interests, as they relate to a fair day's work, with the interests of the organization as they relate to economy and effectiveness in serving the public at a minimum cost. It involves also the interests of stockholders, because of the relation-

ships between costs and profits. Production standards are often used as a basis for incentive plans for wage payment in proportion to production. Their determination affects morale negatively or positively, in consequence, depending on their accuracy and fairness. Time and motion study contributes other values to accounting, production control, cost estimating, plant layout, and other phases of management. The principal objectives of time and motion study, accordingly, are increased *per capita* production, decreased production costs, higher turnover of work in process, a fair basis for wage incentives, greater employee earnings, improved employee morale, and criteria that will make possible the more accurate execution of certain management functions such as accounting, cost estimating, production control, etc. These values involve the differing interests of different groups, which makes their achievement difficult. These objectives are so important, nevertheless, that most concerns would probably use motion and time study if they had no wage incentive system.

The Origin of Time and Motion Study

The origination of time and motion study has been credited to Frederick W. Taylor. He began its development at the Midvale Steel Company in 1881. In his book, *Shop Management,* he said that while foreman of the machine shop, it occurred to him that "it was simpler to time with a stop watch each of the elements of the various kinds of work done in the place, and then find the quickest time in which each job could be done by summing up the total times of its component parts, than it was to search through the time records of former jobs and guess at the proper time and price."[1] By thus breaking down an important phase of the problem into its elements he took a fundamental step in the application of the scientific method to the determination of a fair day's work. From this beginning the technique of production standardization has been developed by Sanford E. Thompson, Dwight V. Merrick, the Gilbreths, and many others who directly or indirectly have come under Taylor's influence.

Taylor placed great weight on motion and time study as a factor in the development of better management methods. He considered it the means of attaining two fundamental objectives of management, high wages and low labor costs.[2] He believed also that "the art of studying unit times is quite as important and as difficult as that of the draftsman. It should be undertaken seriously and looked upon as a profession."[3] In this respect

[1] Frederick W. Taylor, *Shop Management,* Harper & Brothers, 1911, p. 148.
[2] *Ibid.,* p. 46.
[3] *Ibid.,* p. 149.

he was prophetic, for today the time-study analyst is accorded a professional status in most concerns.

The lack of knowledge on the part of the employer, the foreman, and the workman concerning the proper methods which should be used in a process and the proper time which should be necessary were other considerations that directed Taylor's attention to the need for more scientific methods of determining operative production standards. He realized the unreliability of past production records which include, as they must, considerable waste time which has no direct relation to the workman's efforts. He knew from experience and observation that standards set by the foreman on the basis of his practical experience were decidedly unreliable and often led to rate cutting.

The Time-Study Department

It has been noted previously that motion and time study represents an extension of process planning through process analysis into the individual operation or step in the making of a product, or some component part of it. The principal subfunctions of motion and time study have to do with the improvement of general working conditions, except when they involve changes in plant layout or equipment, the development of better methods for performing specific operations, and the setting of standards and rates. The organization that performs these functions is known usually as the time-study department. It is frequently associated with other process planning organizations in a division that may be known variously as manufacturing methods, manufacturing engineering, or industrial engineering. The head of the time-study department reports in Fig. 9.6 to the chief industrial engineer, at the plant level. It should be remembered, however, that time study goes through the same stages in its growth as any other technical staff function. The same basic principles govern its evolution.

The time-study function was located originally in Taylor's planning department. The principal function of this department was production control. Time study was placed there because effective control requires adequate process information and accurate performance standards. The organizational facilities for developing such facts did not exist in American Industry at the beginning of the century. Time study and other process planning functions have been differentiated gradually from production control during the half century that has passed. There are some sound organizational reasons for this. Time study is an important phase of a primary technical staff function, process planning. Production control

is a coördinative staff function that does not require an engineering education in most manufacturing plants.

The time-study function is located under the personnel division in some companies in process industries. This is due to the relation between production standards, wage incentives, employee morale, and labor relations. Such an assignment of functions violates the principle of functional homogeneity. The location shown in Fig. 9.6 is more logical for this reason.

The principal staff operative in the time-study department is the time-study analyst. His work requires a highly specialized background, training, and experience. Practical experience with the processes and tools used in the particular industry is desirable, but it is not a requisite. Time-study consultants frequently set satisfactory standards for operations with which they have had little previous contact. The practical improvement of an operation, on the other hand, requires some practical knowledge of what can and cannot be done with men, materials, methods, tools, and equipment. Such knowledge can be gained only from practical experience. The analyst must have good analytical abilities, combined with initiative, tenacity, and common sense. He can materially benefit or injure the morale of the operative force; therefore he should have a good personality, courtesy, and tact, as well as the courage of his convictions. Accuracy in handling detailed data is of course a requisite. An inaccurate production standard may be worse than none at all. Some engineering training is desirable because many problems border on or overlap the field of engineering; again, however, it is not a requisite. Time-study computations seldom require more than high school mathematics. The time-study analyst has been accorded a professional status as a technical staff specialist, in most large organizations.

Sources of Increased Production

Time study is definitely not a sweatshop device that is designed to speed up the worker. It is not a means of exploiting him by forcing him to do more than a reasonable amount of work for less than a fair day's pay. When these assertions are made in good faith—as they sometimes are—they usually indicate a lack of understanding of the nature and purposes of motion and time study.

If increased production is not the result of a speed up in the sense of employee exploitation, then how is it obtained? As a rule, it may come from any of 7 sources: (1) improved working conditions, (2) improved methods of work, (3) definite service objectives, (4) opportunity for the employee to improve his earnings, (5) training, (6) greater interest in

work, and (7) greater application to the job as a result of greater ability to establish accountability for results.

The workman in Fig 11.1 would probably have had to lift the casting from the floor to the bed of his machine himself 50 years ago, with such help as he could get from his fellow workmen, whereas with the electric hoist shown he can do the job alone, faster and with little physical effort. Two objectives of motion study are the elimination of waste motions and the development of more effective motions. Obviously, the workman can do more work with the same or a smaller expenditure of physical energy if these objectives are achieved properly. A fair standard of production is a measure of the rate of work that can reasonably be expected from a workman; therefore production at this rate becomes one of his individual service objectives. Any reasonable objective has incentive value because the average man finds pleasure in achieving a goal; he enjoys fair competition with his fellows. It enables him to satisfy in some degree his desire for for distinctiveness. A man working toward a definite objective will usually accomplish more with less fatigue because of the stimulus of greater interest. Many organizations enhance this interest by means of a wage incentive plan. It gives the employee an opportunity to increase his hourly earnings above the base hourly rate for the particular class of work. He gains additional pay by maintaining his production above standard. Training must also be credited with a considerable contribution to increased production. In spite of reading an excellent book on golf by an expert, one may continue to slice his drive, whereas a good golf instructor may be able to correct this in relatively few lessons. An employee in the shop may be given an instruction card outlining a new method of doing an operation. Although the production standard may be entirely fair, he may still be unable to maintain it regularly without excessive effort. It is difficult to make complex motions and simultaneously analyze and determine where they are incorrect. The explanations that are necessarily given with training also tend to increase interest. Greater interest results in greater application to the job and the elimination of idle time. Production is increased not so much by working harder as by maintaining a steadier pace of work. Production standards enable us to measure results accomplished by individauls or groups. The establishment of accountability for results also increases interest and application to the job.[4]

[4] The author was required on one occasion to analyze the incentive situation in a plant in which approximately half of the departments were on time standards with incentives. The remaining primary departments were on time standards without incentives. The conditions of work were about the same in other respects. The

It will be noted that these motivations do not depend on the incentive of fear; on the contrary, they are positive incentives. When the achievement of production standards depends on negative incentives, it is probable that some phase of motion and time study has not been performed properly.

Mechanization should be listed also as a source of increased production through time study. Motion study indicates frequently where special tools, holding devices, or other simple mechanisms will permit the employee to increase his rate of production with the same or less effort. Motion and time studies lead occasionally to the redesign of a machine, to increase its productivity. These studies can provide the data for analyses to determine whether the savings from a proposed purchase of a piece of equipment will pay for the cost within the prescribed amortization period.

General Working Conditions

An operation on a part or product is merely a step in the procedure for making the item. The production standard for an operation depends on the general standards of condition, procedure, and performance governing the production of the item. The basic stages in the development of a production standard are therefore (a) the study of the process or method, and (b) the study of the operation or step. The first stage involves the use of various techniques for process analysis. The second involves motion and time study.[5]

It was Taylor's experience, verified by others who have followed him, that standardizing conditions of work and improving equipment and methods increase efficiency in the whole organization. Production is often increased remarkably before any wage incentives are offered. While this brings large returns it may require large monetary expenditures for a considerable time before the desired cost savings are obtained. For example, it may be necessary to study, change, and standardize at considerable expense such items as the gear ratios of machines, lighting and ventilation, materials-handling equipment, and many other general conditions that affect the processing of work. It may be difficult to retain

efficiency of the first group ranged from 110% to 120% of standard; the second group from 70% to 80% of standard.

[5] These are techniques for functional analysis. Their basic significance was discussed in Chapter 3. These techniques may be used by the office manager for the analysis of staff, or secondary, operative procedures as well as by the manufacturing methods manager for the analysis of line, or primary, operative procedures. A procedural flow chart was shown in Chapter 5. The use of a flow chart for plant layout was discussed briefly in Chapter 10.

the support of the organization and its leadership during the period when this expense is being incurred with no corresponding returns.

The general working conditions in the plant should be brought to a satisfactory level, nevertheless, before an attempt is made to set a production standard for a particular operation on a part. The effective performance of an operation depends on the presence of certain general conditions of light, heat, ventilation, transportation, location of facilities, and others that are necessary for any work of the general kind performed in the department or plant.

The standardization of general working conditions is based on the data obtained by process analysis. It may be carried on by the industrial engineering (manufacturing methods) department, following plant layout. This would be true usually when the problem has to do with the layout of a new plant, or the processing of a new model of an old product. It may not be true in an old plant that is operating under conditions of intermittent manufacturing. General working conditions may have been allowed to deteriorate gradually, because there may be no necessity for a periodic review of conditions. There is a requirement for such a review when we must introduce new models annually. A study and standardization of general working conditions should be made before time study is undertaken in a plant with poor general working conditions.

The Principal Phases of Motion and Time Study

The principal techniques for the investigation of conditions, methods, and relationships governing the performance of a particular operation are the stop watch and the micromotion methods. In the former, the human eye is the chief observing instrument, and the stop watch is the principal instrument for obtaining a record of performance time. The latter method depends on the motion-picture camera as the chief observing instrument. It records conditions, motions, and time simultaneously, completely, and in greater detail. Because the stop-watch method is simpler and less expensive, it is the more common. The stop-watch method will be used as the basis of our discussion of motion and time study for this reason. The micromotion method is more scientific and more accurate. It is the basis of some methods for estimating unit operation time, using standard data. The use of such methods for determining "synthetic" times has become more widespread since World War II.

The principal phases of the motion and time study of operations with the stop-watch method are usually:

1. The standardization of working conditions at the work place
2. Motion study of the operation
3. Time study of the operation
4. Analysis of the data and the determination of the production standard
5. The application of the standard
6. The development of standard time relationships

The general nature and contribution of standardized conditions have been discussed.

Motion study is an investigation and analysis of the movements made by an operative in doing a piece of work. The objective of motion study is the elimination of waste effort and the development of a more effective method for the operation. Motion study and time study should be distinctly separated when the stop-watch method is used because of the limitations of the human eye. Motion study should precede time study, because performance time is obviously a function of method. Time study has to do with making an adequate, accurate observation and record of the time required for an operation. Analysis and study of these data frequently lead to remarkable improvements in economy in production. It is not sufficient, however, to improve working conditions and methods, and determine a fair standard. The process is not completed until the standard has been introduced and is working to the satisfaction of both the workers and the management. The application of the standard involves such problems as putting the data in a form that will facilitate use, guaranteeing the standard, educating and training the employee, verifying the standard when for any reason it fails to give satisfaction, etc. In a sense, an objective of operation study is the elimination of operation study, as far as possible, through the development of standard time relationships. These are usually simple mathematical expressions of the relationships between the work factors governing the time required for the performance of a specific kind of operation. They are almost a necessity in certain types of manufacturing. A large concern engaged in continuous manufacturing, for example, must set up thousands of new operations when it commences to produce a new model. The change from the old to the new model may be made in little more than a month. Accurate, direct motion and time study of these operations in such a short period is impossible, except at prohibitive expense. Inaccurate standards are extremely prolific causes of trouble throughout the whole organization.

Before we analyze these phases further, we should consider certain problems involved in the approach to the study.

The Approach to the Time Study

The time-study analyst can accomplish the best results only when he has the coöperation of the whole organization from the general manager to the foreman and the employee. The coöperation of the executive group is necessary from the start, for without it little can be done to standardize conditions and methods. The attitude of the department foreman is often determined by that of the executives above him.

After the general conditions surrounding the job and the method of work have been brought up to a more satisfactory level, operative economy and effectiveness depend on the attitude of the worker, his ability and training, the quantity and quality of work, his incentive to meet the production standards, fatigue, the attitude of the management, etc. The worker's attitude may reflect or be a reaction from his foreman's quite as much as it may reflect his reaction to the time and motion study and the introduction of production standards. His attitude is also related to training and natural ability. The new method for a particular operation may be quite different from the old one, and the standard of production will probably be considerably higher. To master this new method and maintain this standard continuously, the workman must establish new thought habits; this involves mental effort that is seldom welcome. However, with proper training, the average employee can usually master the new method within a relatively short time; but without this training it may be difficult. Obviously the standard of quality affects the ease with which he does this, and therefore is a factor which affects his attitude. Without his interested coöperation, it is difficult to maintain a system of production standards, whereas an interested workman will frequently make suggestions for the improvement of the operation. When an employee realizes that the production standard is fair and that his earning power will be maintained or increased, his attitude toward time and motion study is likely to be favorable. There is little opposition to production standardization, as such, from most of the older, well-established unions. Accurate fair standards of all kinds are essential to good management in any industry. Time and motion study is more likely to improve morale than to lower it, when the resulting production standards are accepted as fair. The choice of the department in which to start time-study work is important. It should be one whose foreman is interested and willing to coöperate. It is desirable to start where there is an opportunity to make substantial savings quickly. Before the work is

started, it should be discussed with the foreman so that his support can be secured.

The workman to be studied should be chosen with the advice and consent of the foremen. In general, a skilled workman should be selected. The performance of the skilled operative can be reduced to a fair production standard through "effort rating," a technique that will be discussed shortly. There are a number of reasons why a skilled, experienced workman should be studied. The probabilities are greater that he has developed good work methods and good work habits. It is likely that he will work at a steady pace. The motions that he uses are usually smoother, more effective, and more uniform.

In general, the approach to the shop executive and the employee is frank and open. It is to the management's interests to set a fair standard of performance, and their coöperation is needed in doing this. The days when an employee was clocked by a time-study man concealed behind a post passed long ago in most modern concerns. Today the development of new standards is more likely to be preceded by conference training courses for foremen and employees on the principles of time and motion study, in which company supervisors and union stewards participate with a view to developing a common basis of understanding of problems in this field.

The Standardization of Local Working Conditions

In discussing the economics of organization and operation we stated as a principle that the determination and use of the best standards of condition tends to improve the quality of work, increase the results achieved, or reduce the cost of operations. The factors of condition in operative performance are largely physical factors that enable the employee, directly or indirectly, to carry on his functions more effectively. In this form, capital enters directly into process, and is directly productive. Such factors condition the methods that may be used in performing a given operation. For example, a hole can be bored in a block of metal by setting it up on the face plate of a lathe or by setting up the job in a horizontal boring mill. Which method should be used will depend on the quantity, the accuracy required, etc. Either method will produce the same hole in the same piece of metal, bored to the same dimensions, and the function will be basically the same—boring a hole. The methods used in the two instances will differ because of the differences in the characteristics of the machines concerned. Obviously the machine is a factor of condition. Inasmuch as these factors thus influence methods, they should be studied

and standardized for maximum effectiveness before an attempt is made to improve the method. As a rule, the standardization of conditions must precede the standardization of functions, even though the general nature of the factors that may be used is determined by the requirements of functions for proper performance.

The problem of standardizing working conditions breaks down into two principal phases: one concerns general working conditions, and the other, local conditions at or immediately around the machine. We have discussed the first phase previously. It deals with those physical factors of environment that condition the performance of all the functions in a general work area, such as a shop department. The standardization of local working conditions concerns the physical factors at the work place that affect the performance of specific operations on specific projects or jobs. For example, when the same operation is repeated on each standard part, it may be necessary to standardize the tools, the auxiliary equipment, the machine, local materials-handling devices, facilities for storing materials at the machine, local lighting arrangements, etc. The effectiveness of local factors depends on the general factors of condition in the work area; in consequence, the standardization of general factors of condition should precede that of local factors.

In the chapters on plant location, the plant and its equipment, materials handling, and lighting and ventilation, many of the important physical factors in production were discussed, and the problems involved in their standardization were taken up in some detail. We shall review here only the principal phases in the standardization of conditions. These are: (1) the determination of the requirements for the proper performance of functions relative to their objectives; (2) the investigation and analysis of the work situation as regards the important factors in performance, and their influence; (3) the selection of criteria of the kind, extent, and degree in which these factors are required for proper performance; (4) the comparison of these factors with corresponding standards; (5) the formulation of a plan for standardizing them; (6) the adjustment of these factors to standard conditions; and (7) the maintenance of these conditions. In a situation, for example, where close skilled work is not required, high quality standards may not be necessary, and a high intensity of illumination is probably not needed. However, before the right size and the proper location of lights can be determined, it is necessary to investigate such factors as the condition of the side walls and other reflecting surfaces, the height of the ceiling above the plane of work, the kind of luminaires in use and their present location, the

intensity of the present light at various points in the work area, the possibility of supplementary local illumination being required at any point, etc. But this information does not have much significance until it is compared with standards of good practice for the particular lighting situation for each of the factors and the relationships that should exist between them. It is possible to get standards information for most factors in production from engineering societies, manufacturers' associations, leading manufacturers, the Bureau of Standards, and similar sources. In some cases the development of proper criteria may require considerable physical research. It becomes strictly an engineering problem in such case. When conditions have been raised to standard, they must be maintained. These conditions will soon deteriorate unless they are inspected periodically.

Motion Study

Motion study involves the investigation, analysis, and study of the movements made by the operative in doing a piece of work. The values that constitute objectives of the particular operation determine the work that must be done and the various performance factors that must be used. The immediate objectives of motion study are: (1) the elimination of unnecessary motions and wasted effort, and (2) greater effectiveness in the performance of those motions that are necessary. Its ultimate objective is to find the method of performing the operation that will give maximum production and minimum costs, with due regard for the quality of the product and the well-being of the employee.

Like any other problem, that of developing better operating methods must be broken down into its elements. The job of making a piece like the part in Fig. 9.7 is broken down into distinct operations by the shop executives, or the process engineer if there is one. An operation is any series of acts, done either by one workman or by a group as a unit, that adds one step to the complete process or in itself constitutes a complete process. For purposes of a time and motion study, the operation itself must be broken down into its elements. An operation element is a distinct phase of an operation which has definite starting and stopping points and which includes the fewest number of motions that can be timed accurately when the eye is the observing instrument. Otherwise, too many factors may be involved, and it may be difficult to determine the causes of variations in the performance of these elements. If they do not have definite starting and stopping points, the records of time and motion may not be accurate and strictly comparable. For a satisfactory motion study, each element should in turn be broken down into the

smallest group of motions that can be observed visually in sufficient detail to make possible their analysis. When a motion picture camera is used, the element can be broken down into its unit motions. A unit motion is a single continuous movement of some working element of the human body that has definite starting and stopping points. With the stop-watch technique, it is usually impossible to break the element down further than a small group of motions, because of the limitations of the eye.

MOTION STUDY SHEET

Dept. No. 120	Part name Base - C. I.	Part No. 100
Foreman John Monroe	Op. name Mill Base	Op. No. 1
Empl. name & No. Edw. Arnold - 567	Qualifications Experienced - good worker	Date

Element	Left hand	Motion symbol	Right hand	Remarks
1 Pick up piece and place in fixture			Locate piece and grasp. Transfer piece to fixture. Place in fixture	Stands throughout operation. Tote box not located conveniently. Reaches for work, bending body slightly at waist
2. Tighten fixture and set piece with babbitt hammer	Tighten fixture jaws		Hold piece in fixture. Reach for babbitt hammer. Strike piece smartly with hammer	No definite location of hammer, often placed inconveniently. No. of blows varies from two to four, occasionally more
	Set fixture jaws firmly		Set fixture jaws firmly.	May lay it down in any space nearby.

Fig. 14.1. A Motion Study Sheet

Inasmuch as it is necessary to divorce motion and time studies, the identical operation elements should be used in making both studies, in order that they may be matched subsequently.[6] It will be seen that motion study is merely an extension of functional analysis into specific operative functions.

As in any other investigation, the results of the motion study should be recorded fully in an orderly form that will facilitate their subsequent classification and analysis. Variants of the simple form shown in Fig. 14.1 have been used widely. The groups of motions making up the work should be recorded and classified with regard to the operation ele-

[6] The first two elements shown on Fig. 14.1 are also the first two on Fig. 14.3.

ments of which they are a part and the body elements that perform them. In most cases, the hands are the most significant elements. A useful motion made by any body element other than the hands must be recorded under the general heading of Remarks. In addition to the information shown, a complete record is usually made of all the conditions surrounding and entering into the job, such as the nature and condition of the machine, tools, materials, etc., and frequently a sketch of the job in its relation to the tool is also made. It is not always possible to tell in advance exactly what data will be necessary for the subsequent work of training, standards maintenance, etc., as well as for the immediate analysis. It is better usually to record too much than too little information, for this reason.

The principal methods of motion analysis are: (1) the quantitative analysis of the motions of two or more operatives relative to time, and (2) the qualitative analysis of motions relative to the requirements of sound motion principles. In the first method, motion studies are made of two or more workmen on the same operation; time studies are then made of the same workmen and operation elements. A comparison of the time studies will show the elements on which each workman appears to have an advantage, and a comparison of the corresponding motion studies will usually show why. By combining the best elements of these workmen, a new method is developed that is superior to the methods used by any of these men. It sometimes happens that an operation does not break down into exactly the same elements for two workmen, even though they have been trained by the same foreman. An examination of the motions used will often show surprising differences in the method of doing them. This may be the case even when the elementary operations are the same. Thus in a simple hand operation studied by the writer, the overall operation time for the two workmen observed was almost identical; but one man happened to have an advantage on certain elements that nearly offset the other man's advantage on the remaining elements. Combining the best elements in both methods resulted almost immediately in a production increase of approximately 40 percent. When only one man does the operation, or time, policy, or possible savings will not permit a comparative analysis, it is necessary to rely entirely on a qualitative analysis of motions on the basis of established motion principles.

Motion principles are fundamental statements that indicate the characteristics and conditions of correct motions. These principles serve as directives for thought in the analysis of operative functions. These were developed first by the Gilbreths, who pioneered in the motion study

field. The following statement of some of them will make clear their nature and application.[7]

1. The most effective method usually is a synthesis of a minimum number of unit motions.
2. Hand motions may be classified in accordance with the kind and number of body elements involved. The work should be simplified to permit the use of motions in the lowest classification with which the work can be done properly.
3. There is a normal work area for each classification of hand motions. Materials and tools should be so located in relation to this area that motions are held to the lowest classification possible.
4. As far as possible, all tools should be prepositioned in fixed locations where they can be grasped in the least time and with the least effort.
5. The motions of the arms should be simultaneous, symmetrical, and opposed in direction.
6. Continuous, curved motions are preferable to straight-line motions involving sudden and sharp changes in direction.
7. Rhythm in work tends to improve coördination and to reduce fatigue. It is a function of time, rather than of distance.
8. The hand is an inefficient holding device. It should be freed for more productive use, whenever possible, by the provision of a mechanical holding device.
9. Whenever possible, completed work should be released mechanically from the holding device, in a manner that will permit its transportation to the next operation by gravity or mechanical means. The objective is the reduction of the use of the hand as a transportation device and the elimination of heavy lifting.
10. Hesitation in making motions should be analyzed, for it may indicate faulty relationships between motions, physical conditions, work habits, etc.

If the operation method has been improved, there must have been some elimination of waste motions, and an improvement in the effectiveness of those motions that are retained. In consequence, the most effective method is usually a synthesis of a smaller number of motions. Hand motions may be classified as: (1) finger motions, (2) motions that involve fingers and wrists, (3) motions that involve fingers, wrists, and forearms, (4) motions that involve fingers, wrists, forearms, and upper arms, and (5) motions that involve fingers, wrists, forearms, upper arms, and shoulders. Figure 14.1 shows some of the detail of a motion study of a milling operation. In element 1, the workman has to reach for new work and has to bend slightly from the waist in doing so. The poor location of the work requires him to make what appears to be a fifth-degree motion.

[7] For a more complete statement and discussion of motion principles see Ralph M. Barnes, *Motion and Time Study*, John Wiley & Sons, Inc., 1937, and subsequent editions.

The higher the degree, the greater the number of muscles that are brought into play, the greater the difficulty of coördinating one's movements, and the greater the amount of energy required. This element violates principles 2 and 3 above. In element 2, the operative apparently lays down his hammer wherever there is a vacant space—a violation of the fourth principle. It is probable also that his left hand is doing too little work in these two elements. There is no evidence of a violation of principle 8. The record suggests, however, that an examination of the design of the fixture might lead to savings. When these conditions are corrected in accordance with these principles, the operative should be able to do more work with less effort because the method will have been simplified in accordance with the first principle. In other circumstances, other motion principles may be applied; but in any instance they serve as directives that call attention to situations that may be improved by further investigation and analysis.

There are direct relations, of course, between the application of motion principles and effective unit motions. An understanding of them is helpful to the motion and time study analyst who may be making only a visual motion study. There were 17 standard unit motions under the original Gilbreth theory. They have been increased since to 18. These standard unit motions, called "therbligs," are:

1. Search: locating an object or place with the eye
2. Find: fixation of eye on object
3. Select: reaching for an object
4. Grasp: seize and clasp firmly with fingers or hand
5. Transport loaded: moving the object to position
6. Position: locating the object in position
7. Assemble: bringing several objects together
8. Use: manipulation and application of tool or device
9. Disassemble: the reverse of assemble
10. Inspect: testing or evaluating results
11. Preposition: position for next cycle in best location
12. Release load: hand releases object after transport loaded
13. Transport empty: removing the hand, the reverse of transport loaded
14. Rest: no action required of operative
15. Unavoidable delay: not chargeable to the operator
16. Avoidable delay: operator responsible for the delay
17. Plan: determining the next step in the operation
18. Hold: retention of the object in the hand, following "grasp" in connection with "use"

The elimination of therbligs, or a more effective arrangement of them, is the basis of improved performance and the conservation of time and

energy. Each therblig usually has certain characteristic requirements for proper performance. They condition the application of motion principles. Therblig 18, "Hold," is one, for example, that can be eliminated frequently, freeing a hand for useful work. The related motion principle is 8. Its application may lead to the design of a double fixture, when we are studying a hand-assembly operation. The hand that is doing unnecessary work, as a holding device, is put to useful work. This improves the effectiveness of performance and conserves time and effort. Applications of motion principles 5 and 7, and certain others, also are involved. Other examples of the relations between other unit motions and principles will be found in books on motion and time study.

The Gilbreths developed a symbol for each therblig. They served the purpose of motion shorthand. The analyst could have entered the symbol for the principal therblig for each group of motions in the proper center columns on Fig. 14.1.

Time Study

Time study may be defined as that phase of production standardization that has to do with making a scientific observation and record of the time required for doing a piece of work. It has been noted previously that the records of time and motion are made simultaneously with the micromotion technique. For best results when the stop-watch technique is used, these records should be the result of independent but related studies.

The time-study analyst's equipment is comparatively simple and inexpensive for the latter method. It consists principally of a stop watch, time-study sheet, time-study board, and a common slide rule. A standard stop watch is shown in Fig. 14.2. Its face is graduated in tenths and hundredths of a minute; the small dial is graduated in minutes, so that when elements take less than 30 minutes, the length of time can be read directly. The watch is started by sliding the side plug up. When the timing is completed, this plug is pulled down, and the hands are snapped back to zero by pressing the crown. Various other types of split-hand and duration-computing stop watches are sometimes used.

The time-study sheet, an example of which is shown in Fig. 14.3, is a device for recording and classifying time observations in a manner that will facilitate their subsequent analysis. Its design may differ greatly between concerns, depending on the characteristics and requirements of the particular time-study system. The time-study board is a device that provides a convenient writing surface and holds the time-study sheet in the proper relation to the point of work and the analyst's eye. It is con-

structed so that the watch may be hung in the upper right-hand corner, and is held on the analyst's left forearm. In making a time study, the analyst usually stands behind the workman, as in Fig. 14.4, to avoid being in his field of vision or otherwise distracting his attention from the job. The slide rule simplifies and speeds up computations.

There are various methods of taking and recording element times. The principal methods are the continuous, repetitive, accumulative, cycle, and overall methods. The continuous method is probably the most common. It will be used to illustrate the problem of timing.

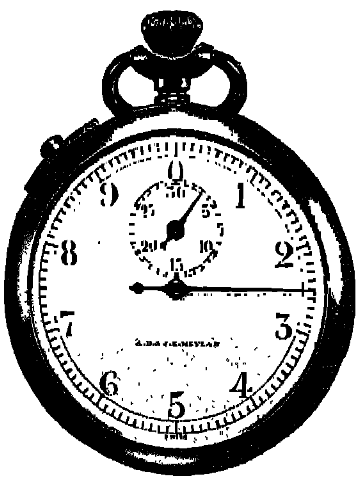


Fig. 14.2. A Standard Stop Watch. (Courtesy, A. R. & J. E. Meylan.)

The operation is first observed and broken down into its elements. The elementary operations are listed in the order of their performance, as shown in Fig. 14.3. The columns with the numbered headings provide space for recording time observations for successive cycles of the elementary operations listed at the left. With the continuous method, the stop watch is started when the study begins, and it runs continuously throughout the whole study. When the workman completes an elementary operation, the analyst's eye travels from the point of work to the stop watch to note the time, and thence to the time-study sheet on which the observation is recorded. An experienced observer can make and record these observations with remarkable speed and accuracy. Figure 14.3 shows that the watch reading for the completion of element 1 in cycle 1 was 0.04 minute; for element 2, 0.10 minute. Therefore the times required for the completion of these elements were 0.04 and 0.06 minute, respectively. One requirement of a scientific record is that it shall provide complete, accurate, verifiable information covering all significant phases of the phenomenon. The continuous method makes it possible to account for all time that is consumed during the study. For example, there was an interference on element 4 in cycle 10; the time consumed by it is shown in the note. Whether the interference is necessary and should be allowed for in determining the standard is a matter of judgment and must be decided later. The accuracy of the time extensions for each element

can be verified easily because their sum total should equal the overall time for the study. An employee can protest a production standard for an operation, through his foreman or the grievance procedure, when he believes that the standard is unfair. The time-study record and computa-

TIME STUDY SHEET

Department No. 120 Part name Base - C.1 Part No 100

Foreman John Monroe Operation name Mill Base Op No. 1

Empl. name & No. Edw Arnold 567 Qualifications Experienced Good Operator Date

El. No.	Operation element	Cycles										Ave.	Best time	Ratio
		1	2	3	4	5	6	7	8	9	10			
1	Pick up piece and place in fixture	04 .04	05 .92	04 1.77	03 .64	03 .51	04 40	03 .79	05 .15	04 7.03	03 .90			
2	Tighten fixture set pc. with hammer	06 .10	05 .97	06 1.83	06 .70	02 .53	05 .45	04 .33	07 22	08 11	06 .96			
3	Advance table and throw in feed.	03 .13	03 1.00	04 1.87	03 73	08 61	05 .50	03 36	04 .26	03 .14	03 .99			
4	Mill base	65 .78	65 1.65	64 2.51	65 3.38	65 4.26	66 5.16	65 6.01	65 6.91	64 78	* 9 15			
5	Automatic return	04 .82	04 1.69	03 .54	02 .42	05 .31	06 .22	04 .05	03 .94	03 81	04 .19			
6	Loosen fixture + remove pc.	05 .87	04 1.73	07 61	06 48	05 .36	04 .26	05 .10	05 .99	06 .87	04 .23			
1		04 27	03 .18	03 04	04 .88	05 .73	04 .63	03 52	04 .39	03 28	03 .16	0.74 0.037	0 03	1 23
2		06 .33	05 .23	04 08	05 .93	06 .79	06 .69	07 .59	05 44	06 .34	07 23	1 10 0.058	0 04	1.45
3		03 .36	04 .27	03 .11	03 .96	05 .84	04 .73	03 .62	03 47	04 38	03 26	0 66 0.035	0 03	1 17
4		66 10.02	65 10.92	65 .76	65 12.61	64 13.48	65 14.38	65 15.27	66 16.13	65 17.03	65 17 91	13 00 0.65	Machine time	
5		05 .07	04 .96	04 .80	03 .64	05 .53	04 .42	03 .30	05 .18	06 09	04 .95	0.83 0 042	Computed	
6		08 .15	05 11.01	04 .84	04 .68	06 .59	07 49	05 .35	07 25	04 .13	05 18.00	1 06 0.053	0 04	1 33
										Average Ratio				4 5.18 1.275
	* Stopped machine to hone work-						8 64 8.13							
	Elapsed time -						0.51							
	Note: Allow 0.4 min for changing work - 50 pcs. in box.													

Fig. 14.3. A Time Study Sheet

tions are subject to check, then, by the employee's representative. The latter may be a shop steward in a union shop. It is important, in any event, that the record be complete, accurate, and verifiable.

With the repetitive method, each element is timed separately, the watch being snapped back to zero when the element is completed and the time recorded. This method eliminates the necessity for making extensions,

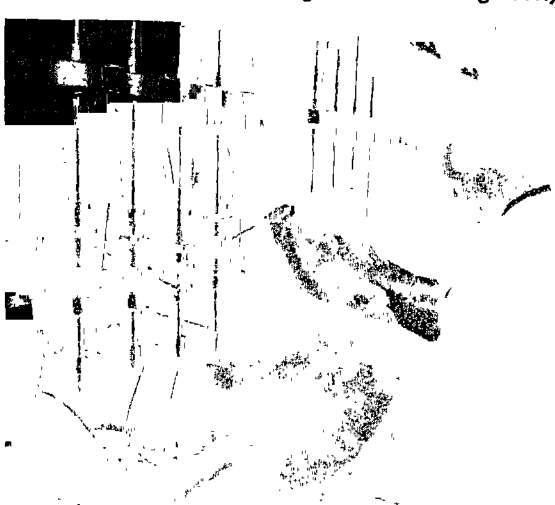
but has certain disadvantages. A variant of the repetitive method is known as the *snap-back method.* Here the watch runs continuously but is snapped back to zero at the completion of each element.

An advantage of the micromotion technique is that it can record accurately the time required for any motion, regardless of the speed with which it is done. Visual observation has its limitations in this respect. Yet accurate standards for short, fast operations are usually quite as important as for long, slow ones. The accumulative and cycle methods are designed to overcome these limitations. The accumulative method uses two or more stop watches. It is seldom used today.

With the cycle method, the watch runs continuously throughout the study. The analyst takes overall times for all elements in the operation cycle, less one. The time for each element is then computed by the means of simultaneous equations. To illustrate, suppose that there are 5 elements in an operation. Their values would be determined as follows:

$$
\begin{array}{ll}
(1) & a+b+c+d = 0.084 \text{ minute} \\
(2) & b+c+d+e = 0.093 \\
(3) & a + c+d+e = 0.087 \\
(4) & a+b + d+e = 0.089 \\
(5) & a+b+c + e = 0.079 \\
\hline
(6) & 4a+4b+4c+4d+4e = 0.432 \text{ minute} \\
(7) & a+b+c+d+e = 0.108
\end{array}
$$

Fig. 14.4. Time Study of a Drilling Operation. (Courtesy of Phil Carroll, Consulting Professional Engineer.)



Each of the first 5 equations represents the average overall time for a number of observations of the cycle of elements shown. To determine the elapsed time for element b, we eliminate Equation (3) against Equation (7), as follows:

$$\begin{array}{lrl} (7) & a+b+c+d+e & =0.108 \text{ minute} \\ (3) & a+c+d+e & =0.087 \\ \hline & b & =0.021 \text{ minute} \end{array}$$

Similarly, it will be seen that the elapsed time for element a is only 0.015 minute. The average observer cannot accurately take element times much below 0.03 minute by direct observation and continuous readings.

There is frequently a question in the mind of the student as to how many observations should be taken in making a study. A standard must be fair to everyone concerned. The study should be continued consequently until all irregular elements have appeared a sufficient number of times to provide adequate data for determining a fair time allowance for them. An irregular element is one that is a necessary part of the work of performing the operation, but is not a part of the regular cycle of elements. An example is the time allowance for changing work that is shown on the time-study sheet in Fig. 14.3. There are, in addition, unavoidable delays that affect all work in an area or a group of machines. Such delays are not directly an effect of any particular operation on any part. The problem of allowances for them will be considered shortly.

The time-study phase of the problem of production standards often seems quite routine. It has been discussed in some detail to make clear its difficulty and importance. Accurate timing requires an analyst who has training, skill, experience, and judgment.

Evaluation of Performance Quality

The quality of performance, as we are using the term, refers to the fidelity with which the employee does his work. It refers also to the excellence of the conditions and methods that he uses. Such performance differences between operatives will affect the speed or pace with which an operation is performed. The term does not refer to differences in employee aptitudes, training, and experience. The latter differences also may be reflected in differences in the speed or pace of work.

There may be some conditions in the cycle of motions for a given element that inhibit smooth-flowing action. This may be reflected in an unusual variance in element time. It is not due, in such case, to any fault of the employee. There are instances, however, in which the variance

is due to deliberate "soldiering" by the employee. He attempts to perform at a lower pace than is normal for him. It is his hope that the time-study record will include the excess time. His objective is a production standard that will give him a "fat rate." This will enable him to make normal incentive earnings with less than normal effort, or better than normal incentive earnings with normal effort.

The variance in performance time, within an element or an operation, is indicated by the ratio of the average element time to the best element time. Some concerns require the time-study analyst to enter the average time and the best time for each element on the time-study sheet, and to compute the variance ratio. This has been done in Fig. 14.3. The statistical technique of standard deviation could be used. Usually it is not, because of the limited body of data produced by a time study.

The normal range of variation in this variance ratio is between 1.20 and 1.30. This apparently represents the normal variation between the average pace of a good workman and the best pace of which he is capable. An operative who has worked continuously on a repetitive operation for some time tends to establish a pattern of work, or work habit, based on his usual pace. This habit tends to pull him back into his normal work pace when he deliberately attempts to loaf. The result tends to be an abnormally high average ratio. The reverse may be true when he has no established work habit. The variance ratio may be abnormally low. A high average ratio could mean that the conditions surrounding the operation are poorly standardized, or the operative is poorly trained. The average variance ratio for the operation shown in Fig. 14.3 is 1.295. This suggests that the overall performance is normal. The ratio for element 2 is 1.45, however. This suggests that a better method of performing this element might be developed, using the motion-study data in Fig. 14.1. It is evident that a time-study analyst should judge the quality of the performance that he is receiving. He cannot rely entirely on a statistical technique, however.[8]

Performance Rating

Men are usually selected for jobs on the bases of certain minimum requirements for satisfactory performance. People differ, however, in the

[8] The use of best times has been inherited, probably, from Dwight V. Merrick, a time-study consultant who was well known during the first quarter of the century. He called the variance ratio a "deviation factor." See *Time Studies as a Basis for Rate Setting*, Engineering Magazine Company, New York, 1919. The use of this ratio is not universal. It does not enter directly into the computation of a production standard, today, when it is used.

interest, energy, integrity, and ambition with which they approach a job, as well as those attributes that make for success on the job. It is quite possible, therefore, to have significant variances in performance rate between operatives on the same operation. The determination of a fair day's work therefore requires that we evaluate the rate of worker performance in terms of the quantity of results produced per unit of time. The quality of worker performance, in terms of consistency, variability, and honesty of effort, is usually evaluated at the same time. The variance ratio, discussed above, is supplementary to a performance ratio, of course. It is not a substitute for it.

Performance rating "is that process during which a time-study engineer compares the performance or effective effort of the operator under observation with the observer's own concept of proper performance as compared to a bench mark."[9] This bench mark is often called the "normal" unit time for the particular operation. A better term might be the "base" unit time. It is the selected average or typical unit time, in some companies, adjusted by a performance rating factor.

The application of this rating to the unit time for an operation adjusts it approximately to the time that would be taken by a qualified employee who is earning his base pay. This is an operative who has been properly selected for the work, and who has completed his learning period. He is not yet working under an incentive system. He is still on a straight time basis, in other words, at his base hourly wage rate. There is a considerable body of practical and research experience concerning the probable increase in his rate of production when he becomes experienced and is working under incentives. It suggests that the increase will be in the order of 115 to 130 percent above base, when the average operative achieves standard performance. This assumes that the man is the primary factor in production on the particular operation, rather than the machine. The superior operative is able to do much better, of course.

There are various systems of performance rating. The following method is described because it provides a simple illustration of the general approach to the problem: Base hourly production, in this method, is represented by 60 standard minutes, or points. The range of incentive performance for the experienced operative is considered usually to be between 70 and 80 points. This means that he will probably produce from 117 to 133 percent above base. The time-study analyst observes the oper-

[9] Society for Advancement of Management, *A Fair Day's Work*, p. 16. Published by SAM, 1954. This is a report of extensive research into the problem of performance rating.

ator's performance. He may judge that the operator in Fig. 14.3 is performing at a 75-point rate. This means merely that the operator is producing in one hour an amount of work that would take the man on straight time 75 minutes to produce. The required adjustment is simple, if this is the case:

Time for hand elements in Fig. 14.3, adjusted by rating factor, (75/60 × 0.183)	0.229 minute
Computed machine time	0.692 minute
Irregular operations	0.008 minute
Base cycle time	0.929 minute

The performance rating of an operation requires experience and trained judgment. The use of judgment does not invalidate the practice of performance rating. This is characteristic of any professional activity that involves problem-solving thought. It does require an organized, thorough training of time-study analysts in performance rating. Given such training, they will agree in the rating of an operation within reasonable limits of error.[10] It is reasonable if the error does not prevent the average employee from making his base wages plus standard incentive earnings with reasonable effort.

The Analysis of the Data and the Determination of the Standard

The principal phases of analysis have to do with developing a more effective method, analyzing the time-study data, determining allowances for fatigue, delays, and irregular operations, and computing a correct production standard. The development of a more effective method involves the analysis of the results of motion studies. It has already been discussed sufficiently. The analysis of the time-study data requires further comment.

With the continuous method, the first step necessarily is the extension of the data. The elapsed time for an element is obtained by subtracting the preceding reading from the present reading. This is shown in Fig. 14.3; it is noted in the upper right-hand corner of the space for the reading. The obviously abnormal values frequently found in the record should be eliminated to make it more truly representative, for otherwise the organization or the operative may be penalized unfairly. Thus both of the abnormal values in the extension for elements 2 and 3 in cycle 5 should be eliminated. An employee may unconsciously speed up on one element and slow down on the next, or the analyst, because of inaccurate observation, may unwittingly subtract a certain amount of time from one element and

[10] The Society for Advancement of Management has training films and manuals that are based on its research work in the field of performance rating.

add it to the preceding or following element when he is using the continuous method. It may be impossible to tell which cause is responsble for the resulting high and low values. But when an accurate record can be obtained of the duration of an interference or delay, such as occurred on element 4 in cycle 10, the extension may be corrected accordingly. If no such record has been made, the extension must be eliminated from consideration. Although the adjustment of the record may be warranted in other cases, it cannot be done arbitrarily, or the basis of confidence in the standard will be destroyed. The record is presumably the result of an investigation which has considerable scientific validity. If there is any question as to whether a value should be eliminated, the record should be given the benefit of the doubt, and the value should be retained.

The selection of a poor mathematical type to represent the typical time *for an operation element may also be a cause of trouble. The three types* found most frequently are the selected average, the selected mode, and the selected median. Of these, the selected average is most common, probably because it is most generally understood. In Fig. 14.3 the total of the extensions for element 2, after the value of 0.02 has been eliminated, is 1.10 minutes. The selected average for the element is therefore 0.058 minutes. The arithmetic average places the greatest emphasis on the extreme values in an array of data. These values in a time-study record are often the extensions that are doubtful, but not sufficiently so to warrant their elimination. For this reason, some concerns use a selected mode. It is the time value which occurs most frequently after the abnormal values have been eliminated. Many believe that this value is probably most typical of normal effort. The median is the middle value in an array of data. The determination of either the mode or the median is affected little by the extreme values in the extensions for an element.

The production standard for an operation is expressed frequently as the hourly rate of production that can reasonably be expected from a qualified worker who has finished his learning period but is inexperienced. It is based on the time per piece, or unit time, for the operation. This time is the base cycle time per unit, increased by allowances for fatigue and delays. The nature of these allowances will be discussed shortly. The following example, using the data in Fig. 14.3, will illustrate the method. The unit times for the power machine elements, Nos. 4 and 5 in this case, are computed from standard data on correct machine speeds and feeds for the operation. No performance rating factor should be applied to these elements, because the operator does little or no work and the machine controls the time. It is necessary to separate power machine elements

from hand elements for this reason. There is a notation on the time-study sheet that there are 50 pieces of work in a tote box and that 0.4 minutes should be allowed for removing the completed work and putting a box of new work in position. It is an irregular operation, one that is directly associated with the regular work cycle, but is not a part of it. An allowance of 0.008 minutes per piece should be made for it. The production standard is computed as follows:

Ave. time for hand elements, adjusted by rating factor, (75/60×0.183 min)	0.229 min/pc
Computed machine time	0.692
Irregular operations, (0.4 min/50 pcs)	0.008
Base cycle time	0.929 min/pc
Allowances for fatigue and delays	0.135
Standard time per piece	1.064 min/pc
Production standard, (60/1.064 min/pc)	56.4 pcs/hr
Base hourly rate for this class of work	$1.25 per hr
Piece rate price, ($1.25/56.4×100)	$2.216/100 pcs

The time required by the average inexperienced operative to perform the hand elements in the above operation should drop from a total of 0.229 min/pc to a total of 0.183 min, when he becomes experienced. He can do little or nothing, probably, to reduce the time required for the power machine and irregular elements. The rate of production for the operator would increase, on this basis, from 56.4 pcs/hr to 59.3 pcs/hr, or approximately 5.14 percent.

The base hourly rate has been defined previously. It tends to correspond to the going rate in the community for operatives who have the basic qualifications for the particular class of work to which they are assigned. They may or may not have had experience with a similar class of work elsewhere. It is assumed that they have completed their learning period, but they are not experienced workers on the particular operation. The actual hourly rate may be above such a rate, as a result of collective bargaining. It may be below the union rate during depressions. The above definition seems to describe the base hourly rate as closely as possible, however. The incentive rate of pay is frequently expressed as a percentage of the base hourly rate. Experience indicates that incentive earnings should not be less than 10 percent of base earnings, if they are to stimulate effectively the interest of the employee in the job and his application to it. Frederick W. Taylor felt that incentive earnings should approximate 20 percent above base. The actual incentive rate varies between firms.

This is a problem in which the personnel department is interested greatly. Fair production standards, fair base rates, and fair incentive rates are important factors in morale development and maintenance.

Some concerns have a policy that sets the incentive rate. It may say, for example, that the total of base earnings plus incentive earnings should approximate a stated percentage of base earnings for the average, experienced operative. We shall assume, for the case in Fig. 14.3, that the particular company has a policy which calls for average total earnings of 120 percent of base. The production standard of 56.4 pcs/hr is too high, in such case. The operative could gain incentive earnings of only 5.14 percent on a piece-rate basis. It would be necessary, then, to lower the standard to conform to company policy. Employee earnings, on a piece rate basis, tend to vary inversely with the magnitude of the production standard. We can make the necessary adjustment by simple proportion in such case. The adjustment would be:

$$105.14\% : 120\% : : X : 56.4$$

$$X = \text{the adjusted standard}$$
$$= \frac{105.14 \times 56.4}{120}, \text{ or } 49.4 \text{ pcs/hr}$$

$$\text{Piece-rate price} = \frac{\$1.25/\text{hr}}{49.4 \text{ pcs/hr}} \times 100, \text{ or } \$2.530/100 \text{ pcs}$$

$$\text{Hourly earnings, @ } 59.3 \text{ pcs/hr} = \$1.50/\text{hr}$$

$$\text{Total earnings rate} = \$1.50/\$1.25 \times 100$$
$$= 120\% \text{ of base, as required.}$$

The student should not conclude that conformity with our incentive policy has increased the cost of the operation. It is probable that the production standard of 49.4 pcs/hr still represents a considerable increase in output above whatever was the standard before the operation was studied. It should be remembered that our industrial engineers have probably improved general working conditions, materials handling methods at the machine, the feeds and speeds of the machine, the tooling of the machine, the method of performing the operation and have taken other measures. It will be assumed that the operative will get good training from his supervisor. The result should be much more production in much less time, with less effort on the part of the operative.

It is possible that the adjusted standard of 49.4 pcs/hr, in the above case, is too low, for reasons that have not been considered. The power machine elements, for example, constitute approximately 75 percent of the

base cycle time. It is probable that the operator could run 4 machines, if the volume of work warranted it.

The distinction between the production standard, the base hourly rate, and the piece price should be maintained. The production standard, once set, should not be changed unless there is a material change in product or process. This standard is expressed in units of time whose value is invariable. The price per piece is based on it, but is expressed in terms of money. It changes from year to year with inflation, fluctuations in the business cycle, etc. Unless this distinction is made, a necessary and legitimate change in a production standard may be branded as "rate cutting." This is untrue if the change is due to substantial improvements in product or process that decrease unit production time. Piecework is only one of the many methods of wage payment in proportion to production that will be discussed later. Because of certain advantages, it is quite common. It sometimes causes labor trouble, partly for the reasons given above. In any system of wage incentives, however, the distinction between standard rates of production and rates of pay should be clear.

The above standard relates to the continuous performance of one particular operation. But the machine must be set up and adjusted before production can start; this may take from a few minutes to a few days. Since this setup time will probably be the same regardless of whether one piece or one million are run, the allowance for it must be made separately. Frequently it is based on independent studies.

The Application of the Standard

More than the determination of production standards is necessary if good morale, increased production, and other benefits from these standards are to be achieved. These standards must be applied properly. The principal phases of application are: (1) the origination of definite written instructions which record the standard and cover the method of doing the operation, (2) training, and (3) the verification of the standard if it is questioned.

The instrument that informs the shop of the production standard and puts it into effect is called by different names in different companies. This instrument is frequently called the instruction card. It is, by any name, a form of process specification that applies to a particular operation. A production standard is a composite of three fundamental types of standards: physical conditions, procedure, and performance. The information conveyed by the instruction card may be classified roughly in accordance with them. Thus the card affords a convenient record of the

condition in which the physical performance factors at the machine must be maintained, if the production standard is to be accomplished. It acts as a standard practice instruction by stating the correct method, reducing the danger of misunderstanding, and preventing unauthorized changes. The card states the standard rate of production to be used in determining the employee's efficiency and in paying wages in proportion to production. It is a guide for the worker and for his superior who trains him. In most concerns, a production standard cannot be put into effect until the foreman has approved it as correct and reasonable. This standard is subject to verification when its accuracy is questioned by the employee or his representative. After its approval, copies probably will be sent to the production control office, the cost department, the payroll division, and any other organization units that may need one. The time-study department keeps the original data and a copy in its files.

We have pointed out that a detailed statement of the correct method is not sufficient. It is extremely difficult for anyone to observe and analyze his performance closely while performing an operation. Modern industry has recognized the basic importance of the foreman's teaching function. Many concerns give him and his assistants considerable instruction in the theory and practice of job training. This is done usually in connection with foremanship training conferences that are held periodically. Foremen are also taught to apply the motion study principles discussed above. The training problems that may arise are too numerous to permit any thorough consideration of them here. An example will indicate their nature. Psychologists recognize a phenomenon known as the "plateau of the learning curve." When a new method is introduced, an employee's production may increase considerably as he becomes familiar with it. He may reach a point, after a time, beyond which it is apparently impossible for him to go, regardless of how conscientiously he tries. This point is probably below the production standard. He becomes discouraged and feels that the standard is unfair. His foreman may put pressure on the time-study department to lower the standard. It is this period, during which new work habits are being established, that is known as the "plateau." The duration of this plateau may be negligible or it may take considerable time. The plateau for a tire-building operation in a rubber factory extended for almost a month and a half. The skill and speed of the worker increase greatly when these new work patterns have been established. He can exceed the production standard easily.

It is the responsibility of management to determine a production standard that is fair to the employee, the organization, and the public. It must

have the authority to do so. An employee has the right to require a reconsideration of the standard, either personally or through his representative, if he feels that it is unfair. Inasmuch as one objective of production standardization is improved morale and better labor relations, it is in the interests of the management to adjust his complaint as fairly and promptly as possible. This is the policy of progressive concerns today.

The Duration Time Study

An adjustment of the employee's complaint may require a check study of the production standard to verify its accuracy. Such a study may be made by means of a duration time study. This is merely a study that is conducted over an extended period of time. The period should be sufficient to assure that all factors affecting performance time have had an opportunity to appear. There should be enough occurrences of each factor to permit an evaluation of it. A duration time study may be used also to get data for the determination of fatigue allowances and delay allowances. It may be used in determining production standards for automatic equipment. The duration of the study is governed by the purposes for which the data is to be used. The study may extend over a number of days. It is, consequently, an expensive and time-consuming form of time study. The duration time study is not used except when it is necessary for research or verification purposes.

The general method of making a duration time study is simple: The time data for hand elements, power machine elements, and irregular elements may be recorded separately. The method of continuous times is used in recording. The time for each element should be computed as the study proceeds. The amounts and trends of these three classes of time values may aid the time-study analyst in his study of the particular problem.

It will be assumed, to illustrate the method, that a study is being made for the purpose of checking an existing standard. The times required for the hand elements, machine elements, and irregular elements are totaled separately. Each total is divided by the number of pieces produced to get the actual time per piece. A comparison between the actual and the original standard element times should locate the area in which the difficulty exists. The following example is based on the case in Fig. 14.3. It is assumed, further, that the operative runs only one machine; that only one piece is machined with each traverse of the table of the milling machine. More than one piece would be finished, of course, if the machine were equipped with some type of multiple-loading fixture. The recorded data covered a half day's operation. Part of it is shown in Fig. 14.5.

DURATION TIME STUDY

Dept. No. 120 Part name Base C.I. Part No. 100

Operator Edw. Arnold #567 Operation Mill Base Op. No. 1

Nature of study Check study. Operator protested standard. Date ______

Op. el.	Hand time	Mch. time	Irreg. El. & delays	Remarks	Op. el.	Hand time	Mch. time	Irreg. El. & delays	Remarks
1-	Pick up piece and place in fixture.								
2-	Tighten fixture. Set piece with babbit hammer								
3-	Advance table and throw in feed.								
4-	Mill Base.								
5-	Automatic return								
6-	Loosen fixture and remove pc.								
C.W.			0.04^{04}	Charge work	4		88^{71}		
1	08^{04}				5		92^{04}		
2	14^{06}				6	97^{05}			
3	18^{04}				1	4.01^{04}			
4		91^{73}			2	06^{05}			
5		95^{04}			3	09^{03}			
6	98^{03}				4		83^{74}		
1	102^{04}				5		87^{04}		

Fig. 14.5. A Duration Time Study

The analyst found, in this case, that Element 5, "Mill base," was taking more than the computed time. The analysis of the data for this element showed the following:

Number of pieces produced during the study		190 pcs
Total time taken by the element during the study		178.03 min
Average time taken per piece		0.937 min
Computed time for the element	0.65 min	
Plus total allowances of 14½% for fatigue and delays	0.094 min	
Standard time for the element	0.744 min	
Standard, adjusted for incentive rate, (120/105.14×0.744)		0.849 min
Excess time taken above standard		0.088 min/pc

The above analysis indicates that the operator cannot earn his base plus normal incentive earnings. It does not show why, however. This may require further checks. It could be, for example, that the operator has not set the feeds and speeds of his machine in accordance with instructions. No change in the production standard is necessary in such case. It could be that he has set them properly, but the actual rate of feed is less than the stated rate for the particular setting. There are other reasons why the excess time might be beyond the control of the operator. It is evident that some temporary adjustment of the standard should be made, when the condition is not the fault of the operative, until the condition can be corrected.

Fatigue Allowances

Some concerns permit their time-study men to allow for fatigue whatever seems fair to them. While an analyst's guess is probably better than that of anyone else in the organization, the problem is too complicated to be solved satisfactorily in this manner. Other concerns use various flat allowances for fatigue. The amount of fatigue that is experienced by an operative tends to vary with the amount of physical effort that he puts into the operation. It tends to vary, therefore, with the ratio of hand time to machine time.

Fatigue is the result of accumulations of poisonous wastes in the system. These wastes are produced by the breaking down of tissue in the body as the result of expenditures of energy. If they are produced more rapidly than the body can eliminate them, they accumulate and produce a deadening effect on the mind and body. This tends to slow up the workman, reduce his production, and increase the danger of accidents. Both management and employees consequently wish to keep fatigue to a minimum that is consistent with reasonable production. An allowance therefore must be made for it. This allowance should enable the average workman, with training, to meet the production standard continuously, but without any detriment to his health or well-being. It is not easy to determine accurately, by scientific procedures, what the allowance should be for a particular work situation. Practical quantitative measures of the causes and effects of fatigue are difficult to obtain. When the blood is forced away from the surface of the forearm by a blunt instrument pressed against it, the time required for the skin to return to its normal color is a function of the degree of fatigue; it will also vary with other physical disabilities of the individual. The carbon dioxide content of the breath will also vary with other disabilities, as well as with fatigue. Most fatigue allowances

consequently are developed from analyses of specific production standards; although they are empirical, they have proved to be practical and satisfactory.

Industrial fatigue is a complex problem because of the large number of factors that may cause it. Poor lighting may cause glare and eyestrain which result in fatigue. Poor ventilation hinders the natural elimination of fatigue poisons from the system. The type of work may require great skill and constant application, or it may create nervous tension, all of which are likely to produce fatigue. The relation of machine time to handling time in doing an operation, the amount of rhythm that can be developed in the work cycle, the worker's posture, the monotony of the work, and many other factors may affect the relation between the operation and fatigue.

It is obviously desirable to reduce fatigue, rather than merely make allowances for it. Methods designed specifically for fatigue reduction have frequently been used. When the fatigue factor is important, certain departments may be completely closed down for a short rest period, in the middle of the morning and afternoon sessions. The length of the period is usually about 10 minutes. The men are urged to relax and get their minds off their work as much as possible. The purpose is to break the monotony of the work, and to give one's body a chance to eliminate partially the fatigue poisons that have accumulated. Improved seating devices which can be adjusted to improve the worker's posture are on the market. Rotating workmen on similar jobs has been advocated as a means of reducing monotony as well as increasing the efficiency of the organization. In some concerns, the playing of phonographs in the shop is permitted at designated times during the work period. As a rule, production is not decreased; on the contrary, it may be increased. These are only a few of the methods that have been used to control and reduce the fatigue factor in production. In addition, the correct standardization of methods and working conditions usually reduces fatigue.

Most professional time-study analysts have developed tables of fatigue allowances for various kinds and conditions of work. These allowances are usually based on data that has been collected by the analyst. There are some good reasons why this is desirable. A separate allowance for fatigue is frequently made.[11] This allowance is applied, as a percentage, to the hand elements in the cycle of operation elements. The machine obviously needs no fatigue allowance. The base cycle time depends partly on the

[11] A lump-sum allowance, covering fatigue and all delays, was used in the previous examples. This was done merely for convenience in illustrating a general method of approach to the determination of production standards.

method of analyzing the observed time-study data. The system of fatigue allowances therefore must be related to the method that is used by the particular analyst. This point probably is not too significant. Competent analysts will use sound methods, and allowances that have been developed accurately with relation to them. They will usually agree closely, therefore, concerning what is a correct production standard for an operation.

The general method of making a practical determination of fatigue allowances can be summarized as follows: An all-day duration time study is taken of an operation within the class of work and conditions that is under investigation. This is sometimes called a production study. The total time taken by all delays is subtracted from the total observed time for the study. A time per piece is computed from the record for the period of best performance when the operative appears to be free from fatigue. The total computed time is subtracted from the total observed productive time for the study. The time difference is due presumably to fatigue. This difference should be expressed as a percentage of the hand-element times in the computed base cycle. This should be done for a sufficient number of cases to establish a fair percentage fatigue allowance for the particular class and kind of work. The following example will illustrate the method for a particular case.

Number of pieces produced during the study	512 pcs.
Total productive time (observed time less delays)	431.2 min
Time per pc for period of best production, without allowances for fatigue and delays	0.825 min
Time chargeable to fatigue [431.2 min − (512 pcs × 0.825 min/pc)]	8.8 min
Proportion of base cycle time taken by hand elements	53.0%
Amount of hand time in equivalent best performance	223.9 min
Percent of fatigue time in this instance (8.8 min/223.9 min × 100)	3.9%

Delay Allowances

A delay may be defined as any interference with an action that impedes progress in the accomplishment of an undertaking. Time is of the essence of accomplishment. A delay can be expressed, accordingly, in terms of time lost as a result of an interference. All delays of production in a manufacturing plant cost money. This cost may reflect the value of the lost time of employees, the lost time of machines, or both. A distinction should be made, however, between avoidable delays and unavoidable delays. The former are delays that can be eliminated promptly by proper employee or executive action. Unavoidable delays are those that cannot be eliminated

promptly. The employee is not responsible for them and management can do nothing about them in the immediate future. Some allowance should be made for them in determining a fair production standard. It may be possible to reduce or eliminate, at some future time, delays that are unavoidable at the present time. This implies that we have no satisfactory solution at the present time; that considerable time, money, and study may be required to develop one. It might be discovered, for example, that a common interference with production is time lost due to delays in moving work up to the men or machines. This might be due to poor production control, poor materials handling, or some other factor that is beyond the control of the employee. This type of delay is unavoidable, so far as he is concerned. It may be necesary to study a number of staff operative procedures before the situation can be corrected. The delay may be unavoidable for some time in the future, so far as plant management is concerned. The employee should be given some temporary time allowance for such delays. He is not responsible for the poor management of the plant.

Delay studies are made for the purpose of getting facts concerning the nature, frequency of occurrence, and duration of recurring interferences with production. The objectives of such studies are estimates of the costs of such delays, the elimination of delays to the maximum extent that is practicable, and fair allowances for those delays that are unavoidable. These allowances usually are added to the base cycle time by means of a percentage ratio. Delay studies are made for a class of work or machines: The kind, frequency, or duration of delays may vary with each class. The record of a delay study should be accurate, complete, and verifiable. It therefore should show all of the time spent, including setup time, machine adjustments and repairs, and irregular operations. Setup time varies with the operation or the class of operations. Separate studies and allowances are made for it. We have seen that irregular elements are associated directly with the base cycle of elements in the operation. The time required for them may be determined from the time-study record for the operation. Machine breakdowns of any considerable duration are major delays. The operative should be assigned to another job or put on a straight time basis temporarily. Allowances for machine breakdowns are not usually included in delay allowances, either.

The principal techniques for studying delays are the duration time study and the ratio delay study. The duration time study has been discussed previously. It must be made for a number of machines or work places to get a fair sample of the conditions affecting their operations. The study at

each machine or workplace must be continued until a sufficient number of occurrences of each kind of delay have been recorded to permit a fair time evaluation of them. The use of the duration time study in determining delay allowances tends to be a time-consuming and expensive process in consequence.

The ratio delay study is much faster. It is claimed that it is more accurate. This method of delay study is a statistical technique for determining the frequency of each kind of delay for a class of work or machines. It is based on the theory of sampling. Research studies made in England and the United States indicate that the time consumed by a delay is proportional to the frequency of observation of its occurrence. This is true provided that a large number of observations are taken on a homogeneous group of work and machines. The number should not usually be less than 500 observations. The reliability of the technique tends to increase also with the length of time over which the observations are taken. The number of observations that is required increases as the number of delays and the percentage of down time increases. No stop watch is used with a ratio delay study.

The general method can be summarized as follows: random observations of operations are taken at a representative number of machines or workplaces. These observations are made by a patroling inspection. Each observation should be made at the same point opposite the workplace. A regular periodicity of inspection is not necessary, since the method depends on random observations. The nature of the employee's activity is entered on the record by means of an appropriate symbol. No time entry is necessary. The employee is asked concerning what he is doing, if there is any question. He knows the reasons for the study, since he is informed in advance. The study is continued until a sufficient body of data has been accumulated. A distribution of the number of occurrences is then made against machines, product, operations, or other work factors that affect the number of delays. The percentage distribution of observations indicates the percentage that should be allowed for each day, in terms of the total work day. Table 2 illustrates the method of analysis. It assumes that the machine is the dominant work factor. The average hourly base rate for this plant is $1.20 per hour. This is low, currently, in most manufacturing communities. The plant is expected to operate for 300 days during the year. It employs 1000 directly productive employees.

Both necessary and unnecessary delays should be broken down into specific kinds and types of delays. It does not follow that a delay is permanently unavoidable because it occurs repeatedly. Each delay should

be studied further with a view to eliminating it. The amount of study that is warranted is limited by the amount of time and expense that can probably be saved. The higher the machine-hour rate and the man-hour rate, the more necessary it is that we eliminate costly delays. The direct-labor cost of delays in this case, exclusive of time for personal needs, was $1.54 per man per day. We shall assume that the above situation is typical of

Table 2. Ratio Delay Analysis

Class of Observations	No. of Observations	Percent of Total	Proportionate Time/Day	Direct Labor Cost/Man
Total observations	1867	100.00%	480.0 min	$9.60/day
Machine running	1520	81.41	290.8	7.82
Downtime	347	18.59	89.2	1.78
Necessary delays	122	6.54	31.4	0.63
Unnecessary delays	178	9.53	45.7	0.91
Personal needs	47	2.52	12.1	0.24

operations throughout the plant; that the experience of the industrial engineering department indicates a possible saving of 40 percent of the total cost of such delays. It is probable, then, that the company is losing approximately $184,800.00 per year, in direct labor, as a result of its failure to study delays. This does not include the cost of unabsorbed overhead expense, due to idle machine capacity.

Studies of Automatic Machines

Production standards for automatic machinery present a different problem. They require a somewhat different technique. Accurate standards for operations done on automatics are quite as necessary as they are for hand operations.

With automatic machinery, all the elements in the regular cycle of operations are done by the machine. Therefore the rate of work is determined mainly by the normal pace of the machine, rather than of the man. The operator does only such necessary irregular operations as removing completed work, replenishing the stock of material needed for the machine, adjusting or changing tools periodically, and other elementary operations that are largely preparative or facilitative. Therefore the only way in which he can affect production is by performing these facilitative elements quickly, and by removing promptly the causes of unnecessary holdups. Inasmuch as the machine does most of the work, an operator usually runs several automatics.

The time for the machining elements, of which the regular cycle is

entirely composed, is usually computed from standard machine data. Therefore the analyst's chief concern is with the interferences, both necessary and unnecessary, with the continuous operation of the machine.

The method of making a time study is somewhat similar to that for a check study. The analyst takes a continuous record of the production of the machine at 10- or 15-minute intervals. Of course he makes a complete record of all physical factors that affect the operation of the machine. When there is a delay, he notes on the record its nature and the time when it begins and ends. The study must be continued until every kind of interference has occurred a sufficient number of times to furnish adequate data for its analysis. To the computed cycle time for the machine elements he adds the time that should be allowed for the necessary delays. Observations of the machine element times are unnecessary for the reasons given above, but allowances for fatigue are made as in any study.

Standards for Group Work

In continuous production or assembly, the completed work that comes from the end of the line is the joint product of several men. There may be more than one man on each operation. A count of the finished work is usually the only record of production available. A standard time for each operation on the part or assembly on which the line works is determined. The standard unit time for the finished item is the sum total of the operation unit times. The standard group operation time is this standard unit time multiplied by the number of pieces produced by the line during the work period. Each workman's time is recorded by a time clock at the entrance to the plant or the department. The total standard time produced divided by the total attendance time of the group measures the efficiency of the line.

Estimated Production Standards

There are two basic approaches to the determination of operative production standards. One of them bases the computation of a standard on data that is obtained by direct observation of an operation. There are two techniques of this kind, the stop-watch technique, and the micromotion technique. The stop-watch technique has been discussed previously at some length. The other approach computes a standard by applying a "standard data relationship" to time data concerning the basic performance factors in an operation. A standard data relationship may be defined as a mathematical expression of the relations between operative functions, physical work factors, and time. These time relationships may be used to

determine the time required for the performance of an operation, operation element, or unit motion. The work has to do with performing a class of jobs, or operating a class of machines. The standard data is obtained originally by one of the direct-observation techniques. The standard data method, therefore, is less fundamental; standards computed by means of standard data may be quite as accurate as those computed directly from observed data, nevertheless.

The use of standard data relationships has many advantages that account for its increasing use. There are situations in which their use is almost mandatory, if accurate production standards are required. A large concern which manufactures certain products on a continuous basis has to make extensive changes in plant layout when it starts to produce its new models. These changes affect the physical environment of manufacturing. There may be hundreds of new operations on both old and new parts. Thousands of new production standards may be necessary, in consequence. The old models are discontinued. Production on the new ones usually is started in little more than a month. Only the most superficial direct time studies could be made in such a short time. The many rate adjustments which would probably be necssary subsequently might lead to restriction of output, labor troubles, and many other difficulties. Direct time studies are not feasible in strictly jobbing industries, such as tool and die manufacturing, either. Here each order may represent an entirely different job; its cost must be estimated and a satisfactory price quoted before the order is placed. Before direct studies could be completed and standards set on each operation, the job might be finished and shipped to the customer. Accurate labor cost estimates require production standards. So do customer promise dates, since these standards enter into the determination of lead time. These standards cannot be determined accurately under these conditions without standard time relationships. In style-goods industries, styles may change annually, and even in the middle of a season when some fad sweeps the country. Here again it may be necessary to set accurately and quickly a large number of new standards. This may also be true of the manufacturer of specialities, such as novelties.

Standard data relationships can be set up in the form of tables, curves, equations, or alignment charts. They enable the time-study department to determine a large number of standards quickly and with reasonable accuracy. A result of these relationships often is a reduction in the work of production standardization and the cost of rate setting. Their development requires the services of analysts with more than ordinary training and ability, however. It involves a considerable investment of time and money.

Standard data relationships can be classified with respect to the degree of refinement that is considered to be necessary or practicable in the analysis of work time. A classification on this basis would distinguish between relationships that express the time requirements for the performance of:

A. *Operation elements*
   1. Machine studies
   2. Job studies
B. *Groups of unit motions, or therbligs*

Both classes are based on the time relationships between physical work factors. The first class expresses the time that is required by an operator to perform the elements in an operation. The second class expresses the time required to perform fundamental unit motions, or therbligs. The element time is the sum of the unit motion times, of course. The operation time is the sum of its element times.[12]

The principal performance factors in an operative work situation are people and things. Some students refer to them broadly as labor and capital, or human and physical factors. The method of developing a standard data relationship for a particular work situation depends on which of the two categories contains the principal work factors. The type of relationship for estimating the time of hand elements and motions will be called a job study relationship in this book. A relationship for estimating the time of machine elements and mechanical motions will be called a machine-study relationship. The latter category will include, however, any relationships for estimating machine setup time. It will also include relationships for estimating time for machine manipulation and adjustment. Such elements are associated with the preparation of the machine for work, rather than with the performance of the basic cycle of operation elements. The relations between these basic work factors may vary over quite a range. At one extreme the man is the principal factor. The operation is composed largely of hand elements. Many assembly operations are examples. At the other extreme, the machine is the principal work factor. This becomes the case, more and more, as the mechanization of industry increases and we move toward higher degrees of automation. There are various degrees between these extremes. The operation in Fig. 14.3 is a combination of hand elements and power machine elements.

[12] Phil Carroll states the principle of the standard data method as follows: "The correct standard for any operation that can be performed within the range of the standard data is a combination of the standards for those elements necessary to its completion." *Time-Study for Cost Control*, McGraw-Hill Book Co, Inc., 1954, p. 25.

Machine Studies

There are two principal kinds of machine study relationships; those for estimating the time for power machine elements, and those for estimating the time for machine facilitation. Relationships for estimating time for machine facilitation have to do either with setting up the machine in preparation for the performance of an operation, or with the adjustment of the machine during the course of the operation.

There are various standard data relationships for computing the time requirements for power machining elements. The more common are simple algebraic relationships that use standard data in tables of machine speeds and feeds. The data varies with the kind of material, the general nature of the operation, the characteristics of the tool, and other factors. The more complicated take into account the strength of the principal working parts of the machine.[13]

The method of developing standard data for setup or other facilitative operations can be summarized as follows: The fundamental operations of this type are determined for the particular kind and class of machine. Each fundamental operation is broken down into its elementary operations. Time studies are made for each elementary operation, covering a range of machine sizes within the particular class. All time observations of elementary operations are made with reference to the normal position of the operative and the machine. It is necessary to record the range of size or condition for those factors that cause time variations for an operation or element. The required time may be a constant for some elements, but a variable for others. Performance rating factors should be applied to the observed time for each operation to reduce the observations to a comparable "normal" time. The standard data that result from such machine studies are set up in tables, charts, or other forms for the quick computation of a standard time for the particular facilitative operation. Standard data for such an operation are given in Table 3 (p. 420). It is a classic example of this practice.

Job Studies

A job study relationship is most useful when the work is manual and the man is the dominant work factor. Such relationships, as the name implies, are designed usually for estimating base operation element time within a range of work or product characteristics. The characteristic that

[13] John W. Hallock's analysis of the computation of machine time on the basis of the strength of machine components, in his book *Production Planning*, Ronald Press Co., 1929, is a well-known example.

controls time requirements for a particular operation on a product might be linear dimension, for example. A job study relationship, then, expresses the effects of changes in work or product specifications on the base cycle time required for the performance of the hand elements in an operation.

Table 3. Raise or Lower Tool Post in Ram, Gisholt Boring Mill

Details of Operation	Raise Post			Lower Post		
	Size of Machine (Inches)			Size of Machine (Inches)		
	42	60	84	42	60	84
	Time in Minutes					
1. Obtain wrench from tool stand, walk to left side of machine	0.09	0.09	0.10	0.09	0.09	0.10
2. Loosen hexagon clamping bolts	0.12	0.17	0.20	0.12	0.17	0.20
3. Lay wrench on table	0.02	0.02	0.02	0.02	0.02	0.02
4. Pull pin, raise post	0.04	0.05	0.05			
5. Pull pin, lower post				0.08	0.09	0.09
6. Pick up wrench	0.02	0.02	0.02	0.02	0.02	0.02
7. Tighten clamping bolts	0.22	0.26	0.29	0.22	0.26	0.29
8. Remove wrench to stand	0.08	0.09	0.11	0.08	0.09	0.11
Total time to raise post	0.59	0.70	0.79			
Total time to lower post				0.63	0.74	0.83

Tool required: open-end wrench.
Normal position of workman: in front of machine.

Source: Dwight V. Merrick, *Time Studies as a Basis for Rate Setting*, Engineering Magazine Co., 1920, p. 88.

The principal areas of application of job study relationships are: (1) jobbing production, when skilled manual work to customer's specifications is required; (2) a standard line of products that must be modified occasionally to meet customer specifications; (3) the periodic or annual introduction of new models. It is assumed for each of the above conditions that the work requires principally hand or hand-machine work for the basic cycle of elements. Some skilled metalworking operations are an example of the first condition. The shafts in a line of small motors may be an example of the second condition. These shafts may have the same general dimensional relationships, although their specific dimensional specifications may differ between the larger and smaller sizes of motors in the line. It may be necessary to modify the standard specifications of a

given model, or to introduce a new model; and the dimensions of the new shaft may differ from those of the established models. It will be assumed that dimension is the principal factor which affects the performance of a typical operation on the shaft. Provided the general dimensional relationships have not been changed, there should be some definite relation between the performance time for the operation on a modified shaft and that for the same operation on the standard ones. If this relationship can be determined, a production standard can be set up for the operation before an order for special shafts goes into production.

Cutting collars for coats in a clothing factory is a good illustration of the third use of job-study relationships. This is essentially a hand operation, although the cutter probably uses an electric knife. Job studies have shown that the time required to cut a batch of collars from a given kind of cloth depends mainly on the perimeter of the collar pattern and the number of "lays" of cloth to be cut at one time. Hence relationships can be developed that will predict the cutting time with satisfactory accuracy. Such relationships facilitate the work of planning for the production of new models of suits. They accomplish many other objectives of standard data relationships that have been noted previously.

The general method of developing these relationships is similar to that for machine-study relationships. There are some differences, however, because a different basis is used for establishing a work relationship. The principal phases are as follows:

1. Complete information on the conditions of work and the characteristics of the product must be obtained for each of a series of operation studies covering the range of work under consideration.
2. A comparative tabulation of these studies should be made on the basis of the elements of the operation and the characteristics of the product.
3. The particular attribute or attributes of the product that control the variation in performance time for each operation element must be determined.
4. The relation between time variations and the corresponding variations in the controlling product characteristics must be determined for the particular operation element.
5. These relationships should be presented in a simple form that will make possible quick, easy, accurate determination of production standards.

The nature and requirements of these phases can best be illustrated by using a simple hypothetical case.

In making an operation study, it is not always possible to tell what condition of work or what product characteristic will govern the performance time for a given operation element on all models or sizes of the product. Therefore a complete record of all physical conditions, in-

cluding product, should be made whenever an operation study is undertaken. Otherwise it may be necessary to make special studies of conditions before job-study relationships can be developed.

Figure 14.6 summarizes several hypothetical operation studies of Y, an operation which is performed on all sizes of part X used in the assembly of all Model M products. These studies are designated S-1, S-2, etc. The

JOB STUDY SUMMARY SHEET

General Information

Part name X

Operation name Y

Material

General conditions

Product Specifications

	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
Length of piece (L) inch	1.0"	2.0"	3.5"	5.0"	7.5"	10.0"	15.0"	20.0"
Thickness, inches	0.5"	0.5"	0.5"	0.75"	0.75"	1.0"	1.0"	1.0"
Weight (W), pounds	1.35#	1.48#	1.52#	2.19#	2.31#	5.64#	5.72#	5.75#
Width, inches	3.0"	3.0"	3.0"	3.0"	3.0"	3.0"	3.0"	3.0"

El. No.	El. name	Ave.	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
a	Const/pc.	0.050	.051	.043	.055	.052	.041	.056	.048	.051
b	Ave. L /in.	0.071	.072 .072	.071 .141	.073 .255	.070 .350	.071 .532	.072 .720	.070 1.050	.071 1.420
c	Ave W /lb.	0.094	.094 .127	.091 .135	.098 .149	.097 .213	.093 .216	.095 .535	.091 .521	.093 .535
d	Const. /pc.	0.113	.111	.113	.109	.116	.123	.106	.119	.108
e	Ave. L /in.	0.037	.031 .031	.038 .076	.036 .126	.037 .185	.035 .262	.041 .410	.039 .585	.036 .720

Fig. 14.6. Example of a Job Study Summary Sheet

significant attributes of part X are listed at the top, and their specifications for the particular size covered in each operation study. The elements of operation Y are listed at the left. The lower figure in each square is the base element time for the particular elementary operation, which was computed from the study data indicated. For example, the base time for element c was computed from the data collected in study S-1, and is 0.127 minutes. The physical factors that condition work, other than product characteristics, were common to all sizes of part X throughout the range of work that was considered. Examination of the data indicates that

elements b and e vary directly with changes in the length of the part. Figure 14.7 shows, for each of the studies tabulated, the base times for these elements plotted against length. Adding the element times for b and e in study 6 gives the total time, 1.13 minutes, required to make a piece of this size for all elements whose performance time varies with its length. The upper line in Fig. 14.7 represents the total time variation for all such elements. If it were necessary to make up a special order of part X to a length of 12.5 inches, the time required for all elements affected by a change in length could be estimated quickly and accurately—it

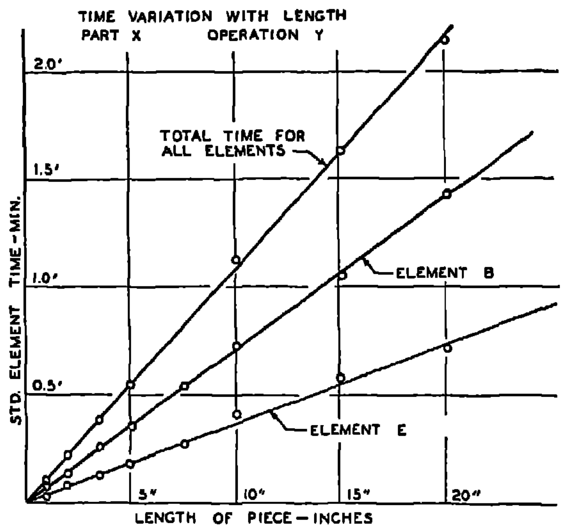


Fig. 14.7. Graphic Determination of Standard Time Relationships

would be 1.35 minutes. Element c varies with the weight of the piece; a and d are approximately constant for all sizes of part X. Similar charts for all variable operations, and tables for all constant operations would make it a simple matter to estimate the base time required for operation Y on any specification of part X. This example is simplified for purposes of illustration. In some cases, the relation between time and the independent variable is often found to be curvilinear rather than linear.

In this example, it would be simpler to express these work relationships in an algebraic formula.[14] Inasmuch as the base times for Element c vary

[14] It has been noted previously that standard data may be set up in the form of tables, charts, formulas, alignment charts, or any other way that is most convenient for estimating standard time with satisfactory accuracy. All the methods of setting up standard data are discussed simply by Phil Carroll in his book on *How to Chart Time-Study Data*, McGraw-Hill Book Co., Inc., 1950.

directly with the weight of the part, a simple ratio of time per unit of weight can be computed for each study for this element. The upper figure in each square for Element c in Fig. 14.6 gives these ratios. In study 3, for example, the ratio is 0.149 min/1.52 lb, or 0.098 minute per pound. The average ratio for element c is 0.094 minute per pound. Similar ratios can be computed for elements b and e on the basis of length. The base times for elements a and d are approximately constant. The ratio for all the elements controlled by a given independent variable is the sum of the average ratios for each elementary operation that is thus controlled. In the case of elements b and e, which vary with length, this would be 0.037 minutes per inch plus 0.071 minutes per inch, or 0.108 minutes per inch. Expressed as a formula, the standard data relationship would be:

$$\text{Base time, operation Y} = 0.108L + 0.094W + 0.163 \text{ minutes}$$

in which L is the length of the part in inches, and W is its weight in pounds. If a special order for part X specified a length of 12.5 inches and a weight of 5.57 lbs, the base time for operation Y would be 2.037 minutes. To this, of course, the required allowances for fatigue and delays would have to be added. An example of an actual job-study formula is shown in Fig. 14.8.

The general conditions under which job-study relationships may be applied have been noted previously. The objectives in developing job-study relationships are fundamentally the same as in machine-study relationships—to improve the speed and accuracy of estimating labor costs, reduce the cost of determining standards and of rate setting, increase the reliability of the standards, make possible the prompt, accurate formulation of standards when extensive changes are made in product and process, etc.

Standard Data Relationships for Unit Motions

Standard data relationships for elementary operations are valuable for the predetermination of standard times for new operations. Their application is limited, however, to a range of a certain class, size, type, or kind of work or product. Such relationships estimate time requirements in terms of those work or product characteristics that control performance time.

The lowest classification into which work can be analyzed is the unit motion, or "therblig." This has been defined previously as a single, continuous movement of some working element of the human body that has definite starting and stopping points. The time required for the execution of a unit motion tends to be independent of work or product character-

LABOR STANDARD TIME DATA
INDUSTRIAL ENGINEERING DEPT.
WESTINGHOUSE FORM 28117

DIVISION	DATE APPROVED	FORMULA NO.	SHEET
Gearmotor	2-1-51	G-100	1 OF 16 SHEETS

REV. NO.																		
	1																	

PART: Drawn Steel Gearmotor Housings - Type "SK" - 5 to 50 H.P. rating.

OPERATION: Draw and trim - or, Draw, Trim and Punch.

WORK STATION: Dept. AB-21 - Punch Press Shop - 150 to 250 Ton Presses #50732, #50733, #50734, and #50735.

APPLICATION PROCEDURE

Production time standards for the operation - "Draw and Trim" or "Draw, Trim & Punch" are determined by applying constant and variable elemental time values in the formula expression given below. The elemental standards are contained in tables 1 to 5. Selection of the appropriate constant or variable elemental time is based on the engineering specification as shown in the drawing Bill of Material.

$$\text{Allowed Hours per 100 pcs.} = A + 2R + \frac{200}{N} + B + C + Q$$

A = Time to pick up sheared blank and position in die (Table #1)
B = Time to remove part from die, rotate 90°, replace in die (Table #2)
C = Time to remove finished piece from die and lay aside (Table #3)
N = Press speed - revolutions per hour
R = Time to close and open clamps - (Table #4)
Q = Time to remove slugs from die - applies <u>only to punch</u> operations (Table #5)

EXAMPLE OF FORMULA APPLICATION

1. - Operation: Draw and Trim
2. - Part: Dwg. 10-A-150 Sub 2 item 16
3. - Area of Sheet Steel Blank - 12" x 20" = 240 sq. inches
4. - Metal thickness - 1/16"
5. - Use press #50732 - press stroke - 1800 rev. per hour

Substituting constant and variable time values from the tables in the formula expression:

$$\text{Allowed Hours per 100 pcs} = .1088 + 2(.042) + \frac{200}{1800} + .0902 + .1050 = .4991$$

Fig. 14.8. A Standard Data Relationship for Estimating Time Study Standards. (Courtesy, Westinghouse Electric Corp.)

istics. The time depends chiefly on the characteristics of the motion itself and the conditions under which it is performed. The time required for the therblig "transport loaded," for example, tends to vary with the distance through which the hand is moved and the weight that is transported.

The basic unit motions were listed and defined when we discussed the subject of motion study. Standard data relationships can be determined for each of these motions, or for small groups of unit motions. They express the relationships between time and certain characteristics or conditions governing the performance of the motion. The data for determining such relationships are obtained by the micromotion technique. An example of standard time data for unit motions is shown in Fig. 14.9.

The use of relationships for applying standard motion-time data has been increasing.[15] These have the advantages of standard data relationships that have been noted previously. These relationships have, in addition, the advantage of broader, more universal application to manual operations than is possible with job studies. These have greater utility also for analyzing and designing correctly the hand elements in a new operation or method, before it is installed. The reason is that motion-time relationships are based on a fundamental breakdown of hand work into universal unit motions. Motion-time relationships have their offsetting disadvantages, of course. Their development is expensive, since it requires considerable micromotion research. The data has permanent value, however. The use of motion-time data and relationships requires some special training. It is probably somewhat more expensive to apply, because of the greater refinement of work analysis.

The method of developing a production standard from standard motion-time data is basically the same as discussed previously: The elementary operation time is the sum of the times for the unit motions that compose it. The unit operation time is the sum of its unit element times, adjusted properly for standard allowances. The production standard, in work units per hour, is the unit operation time divided into 60.

[15] The MTM procedure for using such data is widely known. It is described in H. B. Maynard, G. J. Stegemerten, and J. L. Schwab, *Methods-Time Measurement*, McGraw-Hill Book Co., Inc., 1948, p. 12. The authors are executives of the Methods Engineering Council, a private consulting organization. They define methods-time measurement as "a procedure which analyzes any manual operation or method into a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made." Another well-known method is that developed by Harold Engstrom at the Bridgeport, Connecticut, plant of the General Electric Company. It is described in Ralph M. Barnes, *Motion and Time Study*, John Wiley & Sons, Inc., 1949.

METHODS-TIME MEASUREMENTS APPLICATION DATA

TABLE I — REACH

Case	DESCRIPTION
A	Reach to object in fixed location, or to object in other hand or on which other hand rests.
B	Reach to single object in location which may vary slightly from cycle to cycle.
C	Reach to object in group.
D	Reach to very small object or where accurate grasp is required.
E	Reach to indefinite location to get hand in position for body balance or next motion or out of way.

Distance Moved Inches	LEVELED TIME T. M. U. A Std.	A Hand in Motion	A with C D or B	B Hand in Motion	C or D	E
1	1.8	1.3	2.1	1.5	3.6	1.7
2	3.7	2.8	4.3	2.7	5.9	3.8
3	5.0	3.8	5.9	3.6	7.3	5.3
4	6.1	4.9	7.1	4.3	8.4	6.8
5	6.5	5.3	7.8	5.0	9.4	7.4
6	7.0	5.7	8.6	5.7	10.1	8.0
7	7.4	6.1	9.3	6.5	10.8	8.7
8	7.9	6.5	10.1	7.2	11.5	9.3
9	8.3	6.9	10.8	7.9	12.2	9.9
10	8.7	7.3	11.5	8.6	12.9	10.5
12	9.6	8.1	12.9	10.1	14.2	11.8
14	10.5	8.9	14.4	11.5	15.6	13.0
16	11.4	9.7	15.8	12.9	17.0	14.2
18	12.3	10.5	17.2	14.4	18.4	15.5
20	13.1	11.3	18.6	15.8	19.8	16.7
22	14.0	12.1	20.1	17.3	21.2	18.0
24	14.9	12.9	21.5	18.8	22.5	19.2
26	15.8	13.7	22.9	20.2	23.9	20.4
28	16.7	14.5	24.4	21.7	25.3	21.7
30	17.5	15.3	25.8	23.2	26.7	22.9

TABLE II — MOVE

Case	DESCRIPTION
A	Move object against stop.
B	Move object to approximate location.
C	Move object to exact location.
D	Toss object aside.
E	Move object to indefinite location.

Distance Moved Inches	LEVELED TIME T. M. U. A	B or E	C	D-B Hand in Motion
1	1.7	1.7	1.7	1.5
2	3.6	4.2	4.2	2.7
3	4.9	5.7	5.7	3.6
4	6.1	6.9	7.3	4.3
5	7.3	8.0	8.7	5.0
6	8.1	8.9	9.7	5.7
7	8.9	9.7	10.8	6.5
8	9.7	10.6	11.8	7.2
9	10.5	11.5	12.7	7.9
10	11.3	12.2	13.5	8.6
12	12.9	13.4	15.2	10.0
14	14.4	14.6	16.9	11.4
16	16.0	15.8	18.7	12.8
18	17.6	17.0	20.4	14.2
20	19.2	18.2	22.1	15.6
22	20.8	19.4	23.8	17.0
24	22.4	20.6	25.5	18.4
26	24.0	21.8	27.3	19.8
28	25.5	23.1	29.0	21.2
30	27.1	24.3	30.7	22.7

Multiplying Factor Weight	Factor
Up to 5#	1.00
10#	1.03
15#	1.05
20#	1.08
25#	1.11
30#	1.14
35#	1.16
40#	1.19
45#	1.22
50#	1.25

TABLE III — TURN

Degrees Turned	Leveled T.M.U.	Degrees Turned	Leveled T.M.U.
30°	2.8	120°	6.8
45°	3.5	135°	7.4
60°	4.1	150°	8.1
75°	4.8	165°	8.7
90°	5.4	180°	9.4
105°	6.1		

SMALL: No load or parts up to 2 pounds—Use table value.
MEDIUM: Loads from 2.1 to 10 pounds—Use 1.57 x table value.
LARGE: Loads from 10.1 to 35 pounds—Use 3.0 x table value.

APPLY PRESSURE 16.2 T.M.U.

TURN is a special case of REACH or MOVE. It is accomplished by a turning or torsional motion, during which the hand and wrist turn. When TURN is combined with a normal REACH or MOVE, determine time for TURN and REACH or MOVE from the tables and use the larger value.

Fig. 14.9. Standard Data for Unit Motions

Micromotion Study

Micromotion study is a technique which employs motion-picture photography as the basic means of observing and recording the conditions affecting time and motion in work.[10] It is more scientific and accurate because it makes possible the analysis of work into its ultimate elements, the unit motions of the man or the machine. The motion-picture camera can make a complete record of all functions and factors in work relative to time, regardless of the speed with which the work is done.

The micromotion study technique was invented and developed by Frank Gilbreth and his wife. It may be summarized conveniently on the basis of their theory of motions, methods of recording time and motion, analysis of data, and synthesis of an improved method in accordance with motion principles. The Gilbreths believed that it is necessary, for a correct analysis of work and work relationships, to break down the operation into unit motions. They felt that the maximum benefits to be derived from the development of more effective methods and accurate production standards cannot be achieved otherwise. The Gilbreths developed photographic methods of observing work, a classification of unit motions that would facilitate their study, and motion principles that would aid in evaluating their significance in a given work situation. They called the unit motion a "therblig." The analysis of an operation into unit motions and the application of motion principles have been discussed previously in connection with motion study.

In the beginning, micromotion study was often carried on in a special room in the plant reserved for this form of research. The Gilbreths believed that the studies would be more satisfactory because performance in the shop is often influenced by traditional methods and conditions. A machine of the type required for the operation under consideration was set up in the micromotion laboratory against a large cross-sectioned background. The workman was photographed with a micromotion camera while doing the operation. An important item of equipment was the microchronometer, a fast-moving clock with a black face, white divisions, and white hands; it could be read to 1/4000 of a minute. It was set up in the field of vision of the camera. After the study had been completed, the film was projected on a screen, thus making possible a study of the elementary motions in detail. The cross-sectioned background showed the

[10] This differs slightly from the original definition of micromotion study because of the developments that have occurred in the technique. See F. B. and L. M. Gilbreth, *Applied Motion Study*, Sturges and Walton Co., 1917.

relative distances covered by the motions, and the microchronometer showed accurately the time taken in making them because of the fine divisions of time that could be registered on the film. After an improved method for the operation had been worked out, the operation was usually rephotographed for record and training purposes.

The operation was recorded in the form of a motion cycle chart, often called a "simo chart," to facilitate analysis of unit motions.[17] Time in thousandths of a minute was recorded at the left of the chart. The various members of the body were listed horizontally across the top. The therbligs in which each member participated were listed under each member opposite the time they occurred. The nature of these therbligs was indicated by symbols. The length of time consumed by each therblig was shown by a colored line drawn vertically under the proper member. The colors also indicated the nature of the therblig. Such a detailed, graphic presentation enabled the analyst to determine accurately the extent to which each member of the body participated in the operation, and the nature of its participation. It also gave him a greater opportunity to analyze cause and effect. This made it easier for him to note where conditions and methods could be improved, than would be the case with a stop-watch study.

As a result of their researches and analyses of large bodies of motion-study data, the Gilbreths developed a great many principles of correct motion governing the performance of therbligs, making thereby a great contribution to the science of operative management. Inasmuch as some of these principles have been discussed previously in connection with motion study, we shall not take them up again.

Much of the original Gilbreth technique is in use today. For the most part, these micromotion studies are now made in the shop. This makes untenable the charge that they are unfair because they are made under laboratory conditions. Inexpensive portable floodlights have been developed for the purpose. The development of constant-speed motion picture cameras has tended to eliminate the use of the microchronometer, except for laboratory research. An illustration of a micromotion study is shown in Fig. 14.10. The number of frames exposed by the camera per minute being known, it is a simple matter to compute the time taken by a motion. The micromotion technique has been used by some consultants and large corporations for research purposes. This use has to do with the development of standard time data, and standard relationships for computing production standards, as noted previously. Perhaps the most significant

[17] The chart shown in Fig. 14.1 is a simplification of a "simo chart" for visual observation purposes.

development has been the extension of motion-study training to shop supervision, and union shop stewards in some cases. This has been done for the purpose of developing an understanding of motion principles and their application. The intent has been to improve the quality of on-the-job training by supervisors, and increase the worker's confidence in the production standards.

Operative Production Standards for Office Work

Office production is the work of staff operatives. Much of the work of the office is still manual. The mechanization of office work is increasing,

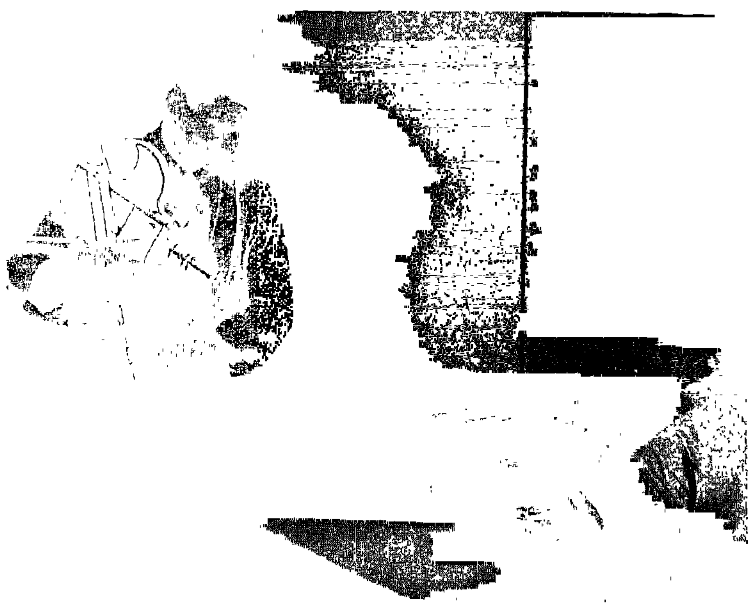


Fig. 14.10. A Micromotion Study of a Bench Operation. (Courtesy, Ralph M. Barnes.)

however. An understanding of the operation of some office equipment requires special training. It does not require an engineering education, nevertheless.

Staff responsbility for the improvement of office conditions and methods falls on the office manager, when there is one. This should include the responsibility for the determination of office production standards. The methods used, when motion and time study is practicable, are similar to those discussed previously. Further attention will be given to the problem of office production when we take up the function of the office manager.

The Significance of Operative Production Standards

Operative production standards, both line and staff, are an important class of performance standards. These standards serve many managerial purposes, in addition to the facilitation of incentive wage payments. Performance standards are necessary for the measurement of results. The degree of accountability for results cannot be determined satisfactorily without fair and accurate measurement. The success of an undertaking depends greatly on the establishment of accountability. This applies to operatives, who are responsible only for work which they perform personally, as well as to executives, who are responsible for the work of those groups which are under their command.

PROBLEMS

1. Part 1827 is a small piece that is manufactured in large volume. Operation 11 on this part is extremely important, and must be done within close limits of accuracy; in consequence, it is given complete inspection. Operation 12, inspection, requires the full time of 4 girls. The work is delivered to them in boxes of 100 pieces each; the boxes are stacked behind each bench, and one box is placed near the girl's left hand. She holds a gauge in her right hand. The girls sit at benches. The following are the principal motions in the inspection operation: She grasps a piece with her left hand and brings it from the box to a convenient position in front of her. Holding the piece in position, she applies the gauge with her right hand. If the piece is satisfactory, she puts it on one pile on her bench; if it is rejected, it goes on another. Because these piles are beyond the box of work, she has to reach with her left arm and bend slightly from the waist. When all the pieces have been gauged, she lays down her gauge, picks up the pile of good pieces with both hands, and puts them back in the box. To do this she has to get up from her chair and stand at the bench. She sets the box of completed work at the back of her bench and puts a new box near her left hand. This requires her to reach, grasp, and carry a load weighing slightly more than 2 pounds over a distance of approximately 2¼ feet. She picks up the rejected pieces, usually with her right hand, and puts them in a nearby tray that is reserved for them. She repeats the operation for the new box of work.
   (a) Make a simple motion-study chart of this operation.
   (b) What motion principles have been violated? Suggest improvements in the method of doing this operation.
2. The following data are stop-watch readings recorded by the continuous timing method of making a time study:
   (a) Determine the base cycle time for this operation, using the selected average time. Justify your action, if you drop any of the readings from the data.
   (b) Assuming element c to be a machining element, how would you determine the base time for this particular element?

Element No.	Work Cycles										Ave.	Min.	Dev. Factor
	1	2	3	4	5	6	7	8	9	10			
a	08 .08	10 .42	07 .78	09 .16	08 .48	04 .83	07 .26	09 .66	08 .04	07 .43			
b	12 .20	14 .56	15 .93	11 .27	15 .63	20 .03	17 .43	15 .81	16 .20	13 .56			
c	04 .24	05 .61	04 .97	05 .32	05 .68	04 .07	04 .47	05 .86	05 .25	04 .60			
d	08 .32	10 .71	10 .07	08 .40	11 .79	12 .19	10 .57	10 .96	11 .36	10 .70			

3. It is necessary to determine the time that should be allowed for fatigue in a certain type of operation. A study has been made over a continuous period of 8 hours. Delays and interruptions of all kinds have been recorded. The number of pieces produced during the period is 4340. The total productive time during the 8-hour period, after the elimination of unnecessary delays, amounted to 420 minutes. The unit time for the best performance during the study was 0.092 min/pc, including necessary delays. Calculate the percentage allowance for fatigue that should be applied in arriving at a standard time for this type of operation.
4. A ratio-delay study has been made for the purpose of determining delay allowances for a type of operation. The time-study engineer made a total of 3415 random observations during the course of the study. The various observations of down time were broken down as follows:

Type of Delay	Number of Times Observed
Waiting	111
Adjusting machine	72
Talking	36
Getting supplies	42
Personal reasons	85
Minor repairs	15
Miscellaneous	12
Total number of delays	373

(a) Calculate the percentage allowance for necessary delays to be used for this operation. Calculate the percentage allowance for each type of delay.

(b) What is the theory underlying the ratio-delay method of determining allowances?

5. In Problem 2 the time-study engineer determined that the performance of the operator deserved an effort-rating factor of 70, as compared with "normal" performance.

(a) Calculate the production standard for this operation.

CHAPTER 15 •

• Fundamental Considerations in Production Control

BUSINESS functions were classified previously into two broad groups, managerial and operative. Managerial functions were broken down into three organic phases: creative planning, organizing, and controlling. Certain functions were surveyed briefly that have to do with the creative planning of product and process. The problem of organizing for the manufacture and sale of the product was studied. The control of production will be examined in the next few chapters.

The Meaning of Production Control

Control was defined in Chapter 5 as the function of constraining and regulating action, in accordance with plans for the achievement of specified objectives. Production control has to do with the coördination of manufacturing activities in the execution of product and production plans and programs. The objectives of these plans and programs are the right quality and quantity of product, delivery of this product to the customer when and where promised, and a unit cost that will permit a reasonable profit. The manufacturing vice-president's office, in Fig. 6.1, probably would be responsible for furnishing a production program to the plant manager's office. Such a program states definitely how much of each kind and type of product will be required during the weeks or months immediately ahead. This program is derived from our sales forecasts and programs. Its use in production control will be seen in the following chapters.

The objectives of a plant production control department are certain values that it contributes to the accomplishment of plant objectives. These are values that grow out of good coördination of production activities, and the avoidance or prompt elimination of interferences with production. These objectives include such values as a minimum of customer back

orders, a faster turnover of work in process, a lower investment of working capital. These include also quicker deliveries, less overtime, less unabsorbed overhead expense, because of a better utilization of machine capacity. Other objectives may be less idle employee time, less waiting in the movement of work in process, and relief of the line executive from much of the routine work of control. Good production control results in greater production of the required quality at lower unit costs, and better customer service.

Economists define production as the function of creating or conserving utilities. These utilities are the capabilities of an economic good or service for satisfying certain needs or desires. This capability is conditioned by such factors such as time, place, form, or possession. The term as generally used in industry refers to the application of men and machines to materials. Good control of these factors in production is most important. Before a production program can be executed, a company must be equipped with sufficient man power which has the abilities required for the varied kinds of work that must be done. This personnel must be trained and supervised properly. There must be some control to insure that this manpower is used as continuously as possible, and with the greatest economy. An adequate supply of materials of the right kind and quality must be available on the job when needed. Machinery of the right kind, type, and capacity must be available in a condition which will permit it to operate constantly and efficiently. The application of these factors to one another at each step in the production process must be so controlled and coördinated that the work flows smoothly.

Production Control and the Kind of Management

A distinction was made in Chapter 3 between conventional, systematic, and scientific management. These distinctions rest chiefly on the degree in which the logic of reflective thinking is applied to the solution of business problems. These concern, therefore, the quality of business plans. The degree of scientific management that exists affects the required quality of executive leadership. The kind of management greatly affects the quality of operative performance and its control, in consequence.

Under the conventional type of management, there is little or no orderly, thorough, preplanning of production. The quantities to be processed are based either on actual orders or on the experience of the head of the production divisions. Orders to process or assemble component parts may be issued when this production executive believes that the time is right. There is no control of available machine capacity. As a result there is no

definite assurance that the machines required for any given operation on an order will be available when needed. The lack of available equipment is a frequent cause of delay in such plants.

Production is not formally scheduled under such management. The superintendent usually has under him a force of men known as stockchasers, whose duty is to follow the progress of work through the plant. These men are responsible for its arrival at the assembly floor at the proper time. The orders for the individual parts of a given product may be issued by the stockchaser who is responsible for it. In the case of a machine, the orders for the heavy parts, such as the base, frame, etc., are issued first because the stockchaser knows from experience that this is necessary if the machine is to be completed and shipped as promised. Orders for the smaller parts which can be produced in a relatively short time are issued later at his discretion. In most instances there is no difficulty in connection with the heavy parts. These are so important that any interference in their production is noticed immediately and eliminated. The smaller parts often cause a delay. Their progress may not be followed closely, because they are small and can be produced with relative ease. In some cases they may be overlooked entirely. As a result, the assembly of the machine may be held up because some small part is not ready at the proper time. It is delayed quite as effectively, in consequence, as though the base or frame were not on hand.

If assembly is delayed beyond the promised shipping date, pressure may be exerted on the production division by the sales department. As a result, the stockchaser goes into the shop to speed up the parts which have failed to arrive at the assembly floor on time. Current production is put aside and the delayed work is placed in the machines. Time is lost while the old setup is being torn down and the machine is being reset for the new job. In addition, there is the extra expense of setups. The rhythm of production is broken and morale may be lowered because of the evident inefficiency. Moreover, when work is put through the shop under pressure, there is always the danger that the quality of the product may suffer.

The decision to work on an order often rests with the foreman. He may be influenced more by the convenient distribution of the load on his department than by the need of final assembly for the parts. This can hardly be otherwise, for he does not have a complete picture of the production situation. Furthermore, he may be persuaded by the more aggressive stockchasers to put their orders through at the expense of other orders. In some plants, hardly 50 percent of the promise dates made to customers are kept. A delayed shipment often interferes with the customer's own

production program, causes him great inconvenience, and results possibly in the loss of his business. One of the best assets of a plant is the reputation for delivering on the dates promised.

This is only a partial summary of the losses that may result from poor production control. As a rule, there are many others occasioned by poor correlation of the tool supply with the needs of the shop, the failure of material to arrive at the bench or shop on time, lack of standardization of materials and methods, etc. It will be seen that such losses are the result of management's failure to accomplish the objectives of good production control.

Production Control Functions and Factors

The basic control functions can be classified in accordance with the relative ease with which they can be separated from line management

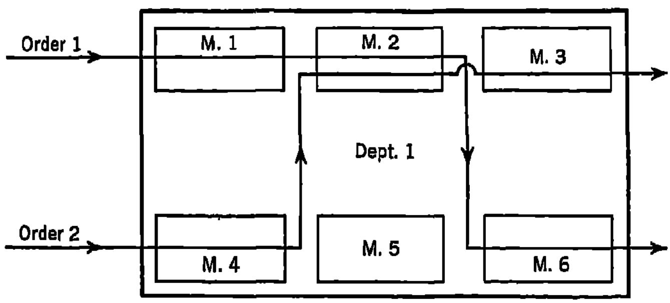


Fig. 15.1. Order Control Diagram

functions, and assigned to a staff control department. This was discussed in Chapter 5. The functions of routine planning, scheduling, preparation, dispatching, and comparison can be assigned to staff most easily. The extent to which this is done depends on the volume of production, the type of product, the type of industry, the type of manufacturing, the attitude and understanding of the control problems by management, and other considerations. The differentiation of these five staff control functions is the basis for the development of the organization and procedure of a staff control department. The remaining control functions are those of direction, supervision, and corrective action. These functions tend to remain largely in the line organization. The staff production control functions coördinate the performance of primary production functions in the shop. These functions assure the provision and availability of the primary factors in production, both human and physical. These assure also the progress of production in accordance with schedules.

There are many technical staff departments in the plant organization that plan or provide these factors. Some of them are the departments headed by the chief engineer, the industrial engineer, the plant personnel manager, the plant supply manager and others who are shown in Fig. 15.5. Production control coördinates the services of such departments with the requirements of the line organization for them. It usually does not perform any functions that have been assigned to particular technical staff departments.

Types of Industry and Production Control

The general type of production control that may be used by a company is affected greatly by the type of industry that it represents. Manufacturing companies may be classified broadly, for production control purposes, in two categories, assembly industries and process industries. This classification rests on the relation between product characteristics and manufacturing methods. A company may operate separate divisions, plants, or departments that represent different types of industry. These organizations may require different types of control, in consequence.

Assembly Industries

In an assembly industry, a number of component parts are united by mechanical means to make the finished product. Each part passes through a series of operations which is peculiar to itself, in most cases. Its manufacture proceeds independently, except that all the parts must be completed at the proper time and placed to permit their mechanical combination into subassemblies or the finished product in accordance with the schedule. In some operations it may be necessary to process two or more components together. The various components may be made from the same or very different materials. Thus the manufacture of a machine tool, such as the drill press shown in Chapter 14 may require a cast-iron base, machine-steel shafts, fiber gears, bronze bushings, etc. Under certain manufacturing conditions, different parts may move at different rates through the shop toward the assembly floor. A manufacturing diagram for an assembled product is shown in Fig. 16.7. It is a simple illustration, but it suggests the complex situations that may arise. A highly developed control system may be required to make certain that the necessary materials, tools, machine capacities, and man power are available when and where they are needed, and that the various activities are properly coordinated with one another.

Process Industries

A process industry is a type in which one or a very few raw materials come together in or near the initial operation. These materials travel together, often in a state of chemical union, until the product is completed. In such industries, all products go through the same general stages of the basic process. The number and kind of operations in each stage may be varied to suit the specifications of different products. In a brass rolling mill, for example, the brass may come from the foundry in slabs about 4 feet long by 1 foot wide. These slabs are passed first through the roughing mills. These are heavy, power-driven rolls that break down the slab, making it thinner, longer, and somewhat wider. The elongated slab is broken down further by successive mills until it arrives at the finishing mills. Here it is rolled to the exact gauge that is desired. In its final form, it is a long, thin sheet that is handled in about the same manner as the sheet steel shown in Fig. 11.12. In the intermediate stages of rolling, the slab may go through a mill one or more times, depending on the composition of the brass and the gauge desired. Rolling tends to harden brass; therefore it must be annealed after each breakdown to restore its ductility. While these operations may vary, all sheets of brass go through the same general stages from the rough breakdown to the finishing mills.

It was seen, during the discussion of organization, that process is one of the bases for the division of responsbility for primary operative functions. It is also the basis of the organization structure for production in process industries, as would be expected. The brass plant may have a superintendent in charge of the brass foundry, and another in charge of the rolling mill; in the rolling mill there may be a head roller or foremen in charge of each mill or group of mills. A process industry differs from an assembly type of industry in this respect. Production in the latter must be organized primarily on the basis of a product or equipment division of functions. This division was illustrated in Chapter 10.

A distinction can be made also between mechanical and chemical process industries. In mechanical process industries, a single material passes through the various phases of the process, undergoing some change of form but not of state; in other words, the material retains its original identity. The rolling mill process is an example. In a chemical process industry, the materials are brought together in or near the initial operation. These materials undergo a change of state and lose their identity in the course of processing. Such industries may be further classified as

synthetic or analytical. In the synthetic process industry, a number of materials are chemically united to form a new compound. Steel is an example: iron ore, coke, limestone, manganese, and other ingredients are fused to produce steel of a predetermined quality. In an analytical process, one or a few materials are broken down into their elements, which are drawn off in some form. The by-product coke industry is the usual example. Coking coal is subjected to heat; the various gases which are driven off are caught and treated to obtain the various coal tar derivatives from which are made dyes, explosives, and many other products.

Semiprocess Industries

Intermediate between assembly and process industries are certain industries that have some of the characteristics of both. These industries may be classified roughly as semiprocess industries. These are characterized by a typical process that breaks down into certain fundamental phases on which the structure of the operative organization usually is based. All products must pass through these phases, but the number of operations may vary considerably within each phase. In these respects, this type is similar to a process industry. But frequently the product is an assembly of a number of component parts. The different parts may be made from different materials which retain their identity throughout the processing. The operation list for each part tends to differ from that for every other part. The product may be affected by changes in style or model. In these respects, such industries are similar to assembly industries. Confectionery manufacturing, printing, clothing, shoe manufacturing, and many textile concerns are examples. The dividing line between assembly and semiprocess industries on the one hand, and semiprocess and process industries on the other, is sometimes hard to distinguish.

Different manufacturing conditions in various types of industries reflect themselves in different control problems. The separate divisions of a company often represent different types of industry. This is why we sometimes find different production control methods in use within the same company. The same fundamental principles apply, however.

Types of Manufacturing

Manufacturing operations may be classified on the basis of their continuity into intermittent and continuous operations. There may be an infinite number of degrees of continuity between completely intermittent and completely continuous manufacturing; hence these terms represent extremes in the scale of manufacturing. The principal factors that govern

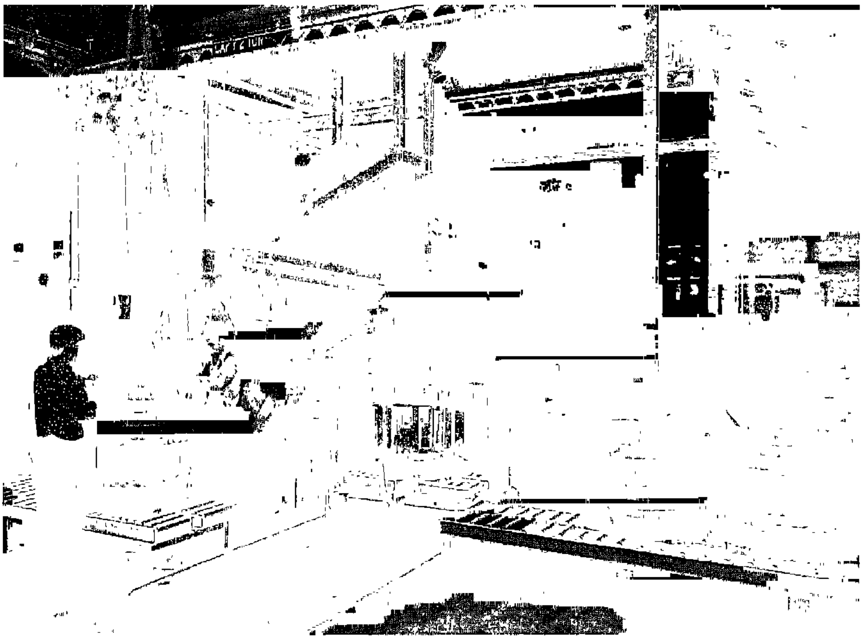


Fig. 15.2. A View of a Foundry, Illustrating the Use of Roll Conveyors in an Intermittent-Process Type of Industry. (Courtesy, The Logan Co.)

the degree of continuity are the volume of production that is required during the manufacturing year, the degree of product standardization that is practicable, and the productivity of machines and men.

Intermittent Manufacturing

Intermittent manufacturing is that type of manufacturing in which labor and equipment are applied continuously to materials for a relatively limited period of time. As a rule, plans are made, materials and tools are procured, and machinery is set up and adjusted for a specific order or lot of the product. A relatively short time is required to complete any given operation on a part or product for the required quantity on order. The setup is then dismantled. The machine is reset and adjusted for an operation on another part or product that is perhaps quite different.

The basis for the division of operative responsibility in an intermittent assembly industry is the classification and grouping of operative functions on the basis of the kinds and types of equipment required. As we saw in connection with Fig. 10.8, this affects the characteristics of factory organization structure. This in turn governs the movement of production between primary departments and the order of operations in the manufacturing procedure. It therefore affects the characteristics and requirements of the control procedure. Furthermore, control has to be extended to each order or lot of product because of the smaller volume of production. The

distances through which materials must be moved are relatively greater. This complicates the internal transportation problem.

Continuous Manufacturing

Continuous manufacturing is that type of manufacturing in which labor and equipment are applied continuously to materials for an extended period of time. Hence plans are made, materials and tools are procured, and machinery is set up and adjusted to produce and supply continuously a large quantity of parts or products to the storeroom or the assembly floor over a considerable time. Once a machine has been put on an operation on a given part, it may be run on this operation for many months, except for occasional shutdowns for readjustment or the replacement of worn tools or equipment. In industries in which mass production of annual models is the rule, many machines may run throughout the year on the same operation.

The most important factors in continuous manufacturing are standardization and the volume of production. Products and manufacturing conditions may be highly standardized; but unless the volume of production for a standard part is sufficient to keep a given machine busy at its normal rate of production, it must be shut down eventually or shifted over to some other operation on another part that requires this type of equipment. Because of the importance of volume, large manufacturing concerns are more likely to be able to engage in continuous manufacturing; but it does not follow necessarily that this type of manufacturing is not feasible for small concerns. For example, the writer once saw in a small foundry the continuous assembly of brass petcocks that were being made for a large automobile manufacturer. The assembly operations were largely hand work. The assembly bench with the canvas belt conveyor running down its center involved no great investment; the concern intended to junk it when the contract was completed. The principal requirement for continuous manufacturing is a sufficient volume of production over a considerable period of time to permit a satisfactory balance of productive capacity between each operation on the particular part or assembly, and a reasonable standardization of manufacturing conditions. In general, it is easier to establish such a balance for hand operations than for machine operations.

Operative functions, in continuous assembly industries are classified and grouped usually on the basis of the products to be made. The general effect on the manufacturing environment and organization structure has been illustrated in Fig. 10.9. The concern, in this case, is manufacturing to a

production program or schedule that covers its production requirements for the next month or more. The concern's problem is to maintain a continuous flow of parts and assemblies from each production and assembly line to meet the requirements of its production program. To do this, production is balanced between each operation on each production or assembly line as accurately as possible. There is obviously no point in breaking up this stream of production into lots or orders, or in controlling each lot individually as it moves to the assembly line.

Continuous manufacturing as a rule is less flexible but more economical than intermittent manufacturing. This is true only as long as the volume of production does not drop so low as to impair seriously the balance of capacity. As a manufacturing business grows, it tends to develop a higher degree of operating continuity. The trend toward increasing mechanization, on the other hand, tends to reduce the degree of operating continuity, other things being equal. The time required to process any given volume of production approaches zero as a limit as the rate of production increases. Other things are not equal, of course: highly mechanized equipment is expensive. It tends to have a high break-even point. Such equipment must pay for itself out of cost savings within a limited period of time. This period depends on the rate of technical progress in the field of process design in the particular industry. A company cannot afford usually to have a substantial loss of machine capacity because of down time for frequent job change-overs. We do not buy the particular piece of equipment when lack of volume and frequent change-overs prevent the machine from paying for itself within the time limit established by top-management policy. A continuous rolling mill, on the other hand, usually produces sheet steel intermittently to specific mill orders. Such a mill can run off a large tonnage of sheets of a given gauge and width in a relatively short time. The cost of change-overs has to go into the cost of the product, obviously, but the continuous mill still is able to produce low-cost sheets.

Hybrid Types of Manufacturing

There is a range within the extremes of operating continuity in which conditions have some of the characteristics of intermittent manufacturing and some of continuous manufacturing. This range has been shown in Fig. 15.3 on the scale of volume and continuity of operations. It extends from a condition of semi-intermittent manufacturing to and including a condition of semicontinuous manufacturing. These limits have been indicated by wavy lines, because degrees and conditions of continuity shade into one another. There are various hybrid types of manufacturing

in concerns whose operations fall largely within this middle range. It may be necessary in such concerns to design and apply some hybrid types of production control to fit the particular conditions. These conditions will be illustrated when we discuss briefly the problem of hybrid control methods.

It is evident that the type of manufacturing will greatly affect the type of control that will be most economical. Any industry may find it advisable or necessary to engage in either intermittent or continuous

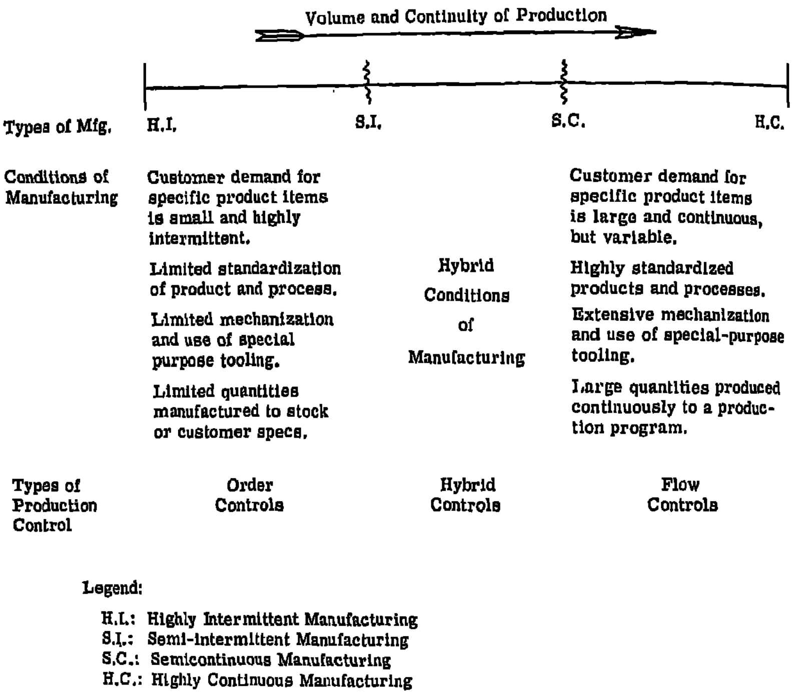


Fig. 15.3. Operating Continuity and Types of Production Controls

manufacturing. The extreme degrees of continuity may be found, furthermore, in different concerns in the same kind of industry. We usually think of automobile manufacturing as being a highly continuous assembly industry, and it is. There are, nevertheless, a few concerns that manufacture special-purpose automotive vehicles that are virtually custom built. Their production volume is very small. Their manufacturing operations are highly intermittent. The type of control that will work in an intermittent assembly industry usually will not work in a continuous industry of the same kind, and vice versa. The production control methods

that would be effective in General Motors, Chrysler, or Ford plants could not be used by such small automotive concerns.

Types of Production Control

There are two general types of production control: order control and flow control. The type of industry influences the detailed characteristics and requirements of control procedure. The type of manufacturing has a direct and important influence on the type of control. Our distinction between the two types of control is more closely related, in consequence, to the distinction between types of manufacturing. We have attempted in Fig. 15.3 to diagram the general relations between these types.

Order Control Methods

Order control methods are based on the control of the progress of an order, or lot of work, through the successive operations and departments in its processing. As indicated in Fig. 15.1 each order must arrive in the right department and work center, as specified by the operation layout sheet for the part or product.[1] The required operations must be performed in time to permit the shipment of the order from the department in accordance with its schedule. There must be sufficient machine capacity of the right kind when the work arrives, and tools and materials must be on hand. The control methods must indicate the status and location of the order at all times, and its progress in relation to its time schedule.

Flow Control Methods

Flow control methods are based on the maintenance of a predetermined rate of flow of work from each machine or work center; the crosshatched areas in Fig. 15.4 represent this flow. It will be assumed that the capacity of Department 2 is devoted entirely to the production of part X. The materials and work in process must flow to and from the machines at a constant rate, as indicated. To accomplish this, the machine capacity applied to each operation must be balanced with the other operations on the part. The rate of tool consumption is determined, and an adequate supply is maintained continuously in the shop tool cages. The control methods in this case must indicate at all times the current and cumulative

[1] A work center is any area in the shop which contains like machines or produces a particular kind of work. In intermittent manufacturing, it may include one or more machines with the necessary space for the workman and the storage of materials. In continuous manufacturing, it may include a series of machines whose functions are related to one another directly, by physical contiguity, complementary relationships and conveying equipment, to form a production or assembly line.

quantities produced on each production or assembly line, in relation to the scheduled rate of flow.

Hybrid Control Methods

The transition from highly intermittent industries, such as jobbing tool and die shops, foundries, drop forge shops, etc., to highly continuous industries, such as radio, washing machine, automobile, and other continuous assembly plants, is accompanied by a gradual change in the type of production control from pure order to a pure flow control. There may be many hybrid types in between these extremes. An example is the concern that applies flow control to its high-volume products, and order

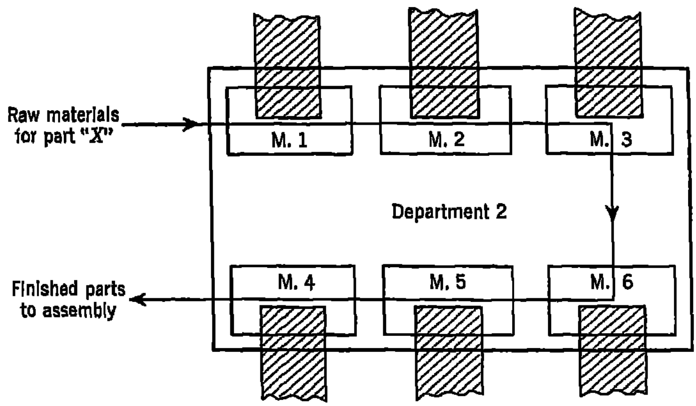


Fig. 15.4. Flow Control Diagram

control to its low-volume lines. Many airplane manufacturers found during World War II that their production problems required continuous assembly and intermittent parts fabrication. It was necessary for them to use some form of flow control in their assembly plant, and some form of order control in their parts plant. The best-known of these hybrid types probably is block control. It is found most frequently in plants with hybrid manufacturing conditions. With this form of control, orders or batches of product are assigned to blocks of work, usually in accordance with their due dates. These blocks represent approximately equal amounts of work in each department, and therefore equal blocks of time. All blocks must go through the same fundamental phases of the basic process. The production division must be departmentalized on the basis of these phases. Manufacturing capacity must be balanced between departments, for otherwise these blocks will move through different departments at

different rates. The blocks of work are numbered serially, as they are released. They must be processed in this order as a rule. The progress of the blocks through their successive departments can be shown easily by means of relatively simple reports and control devices. Any order or batch in a block which is held up can be spotted quickly. When assembled products can be manufactured under these conditions, differences in styles, sizes, and models can be taken care of without great difficulty. These conditions are found frequently in either process or assembly industries under conditions of semi-intermittent or semi-continuous manufacturing. Shoe factories, clothing factories, printing plants, and textile plants often offer excellent examples of block control.

A brief glance at the hundreds of industries, each of which may include thousands of concerns manufacturing a great variety of products under widely differing conditions, makes the problem of production control appear baffling because of its complexity. The analysis of a control problem may be greatly simplified if we classify it roughly by type of industry, manufacturing, and control, and then remember that any such problem can be broken down into the organic phases of control: routine planning, scheduling, preparation, dispatching, direction, supervision, comparison, and corrective action.

The next few chapters will trace the influence of these control functions on the control of production. The analysis will begin with highly intermittent manufacturing and end with highly continuous manufacturing. The discussion of hybrid types will be left to books that specialize in production control. First, however, the organization structure of the manufacturing division must be examined further.

The Organization of the Production Division

Production is one of the organic functions of a manufacturing business. It has been pointed out that the devolution of an organic function with business growth results gradually in an increasing separation of managerial and primary operative functions. Managerial functions break down into line and staff activities; the latter into coördinative and technical staff functions. These staff functions may be appended to the line organization at any service level where they may be needed. As we approach the level of primary operative performance, technical staff services have to do largely with technical facilitation, rather than with creative planning.

The line organization of the division extends directly from ownership to primary operative performance. The line organization of the company shown in Fig. 6.1 extends from the board of directors, through the

president, executive vice-president, vice-president for manufacturing, and the general manager, to the plant managers. It is continued in Fig. 15.5 from a plant manager, through the assistant plant manager, division superintendents, foremen, and line supervisors, to groups of primary operatives.

This company is probably a large corporation, since it is engaged in multiplant operation. The plant organization in Fig. 15.5 probably employs about 1500 primary operatives. No facts are available concerning staff-line ratios for the company. Such ratios tend to vary with the size of the concern, the kind of function, the type of industry, and the type of manufacturing. It is probable, however, that this plant has a total personnel strength that is somewhere between 2300 and 2700 employees. There is an increasing separation of administrative management from operative management with increasing organization size. Such a separation is well advanced, evidently, in this company.

The general manager is regarded usually as the lowest officer in the ranks of line administrative executives. The general manager is accountable, in this case, to the vice-president for manufacturing. He is responsible for the execution of the current production program of the manufacturing division, subject to general direction. Each plant manager is accountable to the general manager for the execution of that part of the program which has been assigned to his plant. The general manager receives such supporting services from the staff of the vice-president as he may require. He will need, for control purposes, weekly and monthly reports of the results accomplished by each of his plants as we progress through the month, the quarter, and the year. These results must be expressed in the same terms as those used in setting up plant objectives in previously approved manufacturing plans. These terms have to do, in general, with the quantity and quality of goods produced and shipped, and the time and expense required. There are in addition many long-range values that must be taken into account.

The plant manager is supported in the management of his plant by his staff. The duties of the plant staff were outlined briefly during the discussion of Fig. 6.1. The functions of the chief engineer and the industrial engineer have been discussed previously in some detail. The duties of the other plant staff executives will be discussed in the chapters that follow. The plant manager will probably need, for control purposes, reports of the results accomplished by each plant division and department. He may want certain reports daily or weekly, as time moves through the month and the quarter. It probably has been noticed that the time span of control has been shortening as we approach the point of operative

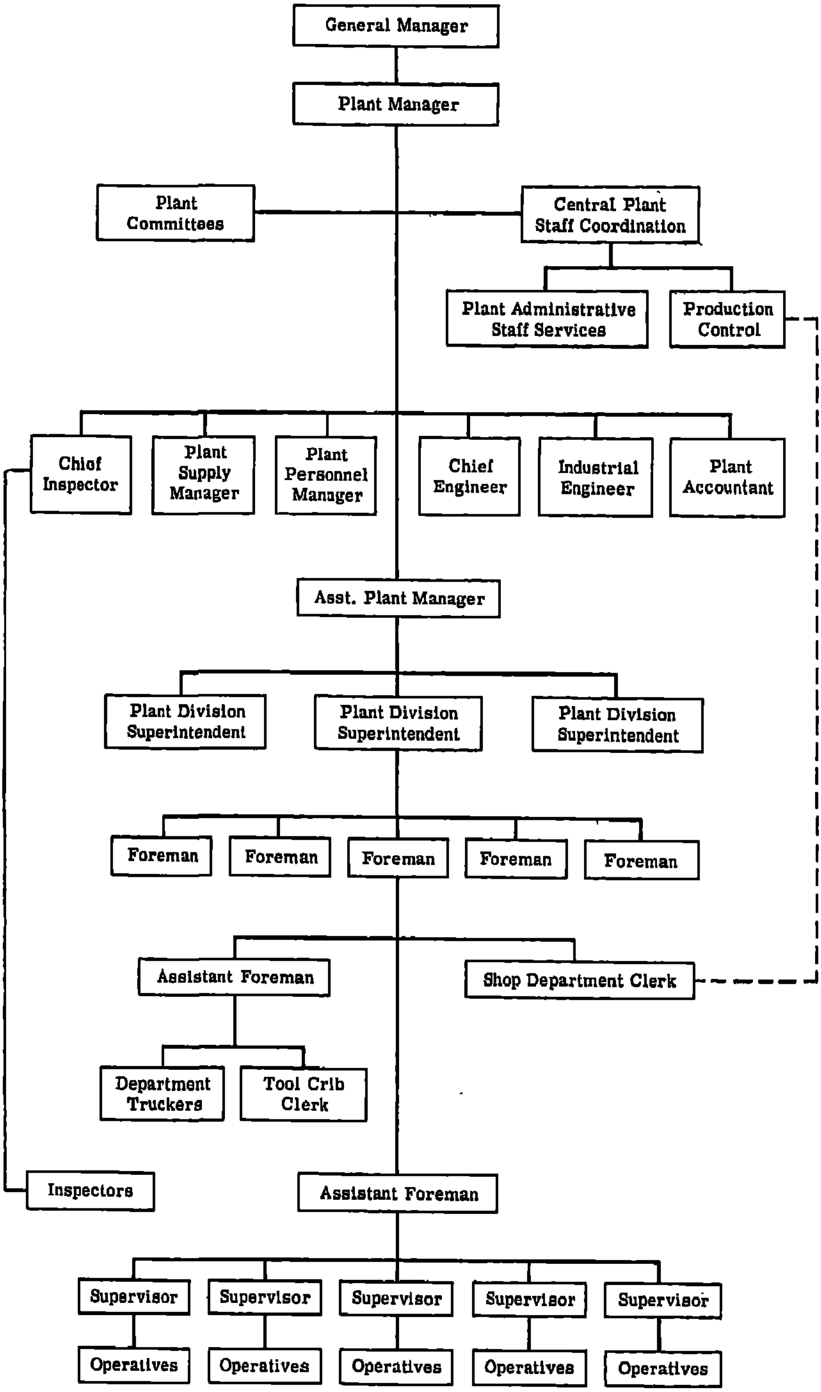


Fig. 15.5. Plant Production Organization

performance. The manager also will want reports of results from his staff departments, relative to payroll and other expenditures, since these departments represent overhead expense. He is primarily a major operative executive who gives general direction to the execution of his plant program. He may also have some important general administrative responsibilities for his plant, including some responsibilities for long-range planning. This is increasingly true as increasing managerial decentralization on a product-line, profit-center basis is developed.

The assistant plant manager exercises day-to-day direction and supervision of the line divisions of the plant. He coördinates interdivisional corrective action. The assistant manager can call on the plant managers staff for support. Three divisional superintendents report to the assistant plant manager in Fig. 15.5. The maximum number who can report to him with further plant growth will be limited by what is regarded by the plant manager as an effective span of executive supervision. This is not likely to be much more than 6 or 7.

The division superintendents are concerned largely with the daily and weekly coördination and control of production in the shop departments that are under their command. These superintendents receive the support of the plant production control department in this connection. They are responsible also for seeing that their departments operate within established expense budgets during the month, and meet whatever operating ratios are set up as criteria of good performance. The basis of divisional organization is fundamentally the basis on which primary operative functions are grouped in units of supervision under a first-line supervisor. This basis, as we have seen, may be product, process, or some dominant performance factor that requires some special skills and knowledges for its use. The superintendent may have only a clerk and a stenographer in his office. This office should keep a minimum of records and files. The superintendent should receive prompt information concerning his current operations from the various staff offices. All communications concerning plans and policies affecting his division should clear through the superintendent. The functions of his office usually increase, as the plant grows. It is necessary to decentralize certain staff functions within the plant. Production control is likely to be one of these functions.

The foreman in a modern plant is a department manager. He is performing more managerial functions, in addition to his traditional work of supervision. This is in line with the trend toward the maximum practicable decentralization. There is a trend, in consequence, toward the organiza-

tion of larger primary departments. This is necessary to make a job that is big enough to attract a competent department manager. The concepts of spans of executive supervision and operative supervision govern what is an optimum departmental size. A department of the size shown in Fig. 15.5 must be broken up into practical units of supervision. Each unit is under the direction of a supervisor. These supervisors report to a line assistant foreman, who is second in command to the foreman. The shop clerk and the assistant foreman in charge of the tool crib and the departmental truckers are staff. The shop clerk usually performs time-keeping and production-control functions for the department. Figure 15.5 indicates some considerable decentralization of the production control functions. This function may be centralized under conditions of continuous manufacturing, for reasons that will be seen shortly. The foreman, assistant foreman, and line supervisors are supervisory executives. Their work falls in the field of minor operative management.

The departmental inspectors are shown reporting directly to the chief inspector of the plant, in Fig. 15.5. They may actually report through some intervening levels of supervision in the inspection organization. The responsibility for quality rests on the organization that produces it, the line organization. The inspection organization is merely responsible for a fair, accurate determination of the quality that has been produced, and its conformity with quality standards for the particular operation or product. There is always a danger that the line organization may stress quantity at the expense of quality, to meet a delivery date or for some other reason. It is undesirable also to have an executive evaluate his own results. For these and other reasons, the quality control organization, including inspection, is usually separate from but directly related to the production line organization.

The chart in Fig. 15.5 merely indicates the presence of various plant committees. These committees aid the plant manager in accomplishing a meeting of minds between his subordinates concerning planning and policy-making problems having to do with plant operations. The number and nature of these committees is a matter for the decision of the plant manager.

The production control department, in Fig. 15.5, is concerned with the interdepartmental coördination of production. It is a staff department. It does not exercise any control in its own right. It performs a valuable service by assisting the line organization in the control of its operations. The organization of the department is based on the requirements of the

five staff phases of control. The size of the department depends on the types of manufacturing and control that are necessary.[2] The department may find it necessary to operate a centralized staff control of production under conditions of continuous manufacturing.

Decentralization and the Control of Production

Delegation is the managerial process by which an executive releases and assigns certain of his functions, responsibilities, and authorities to subordinate positions. The executive remains accountable, however, for the proper performance of the delegated functions. An executive can delegate his responsibilities, but he cannot abdicate them.

Decentralization in business organization is a condition under which certain functions of the organization are performed for its responsible head by subordinate personnel on lower echelons. These functions may be operative or managerial. It is evident that decentralization depends on and requires delegation. The decentralization of operative functions should be accompanied by a corresponding decentralization of managerial functions. This is particularly true when decentralization is accompanied by the geographical dispersion of operative functions, as in multiplant operations. The general rules governing decentralization were stated in Chapter 3.

Primary operative functions may be decentralized without a corresponding decentralization of the managerial function of control. It is necessary, in such case, to develop a procedure for a centralized control of operations. Figure 15.3 shows the general relations between operating continuity and types of control. An examination of the diagram, in relation to the rules governing decentralization, will suggest why production controls tend to be highly centralized in large plants engaged in continuous manufacturing. These controls tend, conversely, to be decentralized in plants engaged in intermittent manufacturing. The maximum decentralization of control, that is practicable under given conditions of manufacturing, is desirable. The reasons why this is so were discussed in Chapter 5. They will be examined further in the following chapters on production control.

[2] A preliminary survey of the problem, made in 1954, suggested that the number of employees in the production control department tends to vary directly with the number of direct, or primary operative, workers. The average concern of 1500 directly productive operatives would employ approximately 38 employees in its production control department. An average figure cannot be applied directly to a specific case, of course. It must be modified to reflect the specific manufacturing conditions. See A. W. Baker and R. C. Davis, *Ratios of Staff to Line Employees and Stages of Differentiation of Staff Functions*, Research Monograph 72, Bureau of Business Research, Ohio State University.

Sales Forecasting and the Control of Production

The sales forecast is the starting point of production planning and control. Goods obviously are manufactured for the purpose of satisfying customer needs. It is a little difficult, at least, to sell goods for which no one has any need or desire, although it has been done. The company hopes to sell these goods at a price that will leave a profit. It is equally evident that these goods must be manufactured at a competitive cost in advance of their sales and distribution to the customer. It does not follow, however, that we must or should manufacture directly to customer demand.[8]

The volume of demand greatly affects the type of control that may be applied, and the extent to which it may be developed. The degree to which probable demand can be forecast depends on the nature of the products, the volume of demand for them, the availability of adequate sales and production information by product lines for the company and the industry, as well as on the use of sound forecasting techniques. Producers' goods industries usually have greater seasonal and cyclical variations than consumers' goods industries. A process industry making a highly standardized consumers' good, under continuous manufacturing conditions, can forecast its demand fairly accurately. On the other hand, a highly intermittent assembly industry manufacturing largely to order cannot forecast the demand for its products to the same extent; for the most part, it must handle the demand as it arises. The industry that is engaged in continuous manufacturing can control production more effectively than the other. It has greater ability to anticipate and prepare for the demand. The continuous industry can apply certain measures which will indicate the extent to which the plant can meet it.

Many manufacturing concerns, particularly those making large quantities of standard products, maintain statistical departments. Such departments collect and analyze regularly a wide variety of business statistics. The statistical department estimates the probable sales during a forthcoming period from its analyses of business statistics for the economy, the industry, and the company, including reports of probable conditions in its sales territories. This forecast must usually be submitted to the company's executive committee for its concurrence. Such a committee is responsible in Fig. 6.1 for recommending to the executive vice-president what and how much of each product item shall be produced and sold.

[8] The nature and importance of the sales forecasting function was noted in Chapter 7.

It must harmonize the views of the sales, production, and financial divisions. The sales division naturally wishes to sell the lines which have the least sales resistance and the largest margin of profit on sales. The production division wants to make those lines which permits the maximum utilization of men and machines, which can be handled with the greatest ease and lowest cost in the shop. The financial division is interested in the sales and production programs in relation to capital turnover because it must finance them. It is naturally conservative when it comes to expansion or changes in policy which involve the expenditure of considerable sums. The details of the sales and production programs involve the consideration of many factors, such as seasonal variations in demand, the amount and kind of plant capacity available, the economic size of inventories, the availability of materials, storage capacity, the allocation of product lines to plants, etc.

The manufacturing division makes up a production program for the period under consideration, on the basis of the sales program. In most cases the central manufacturing control department prepares it under the general direction of the manufacturing vice-president. This program is submitted to the committtee for concurrence, as indicated above. This program is an estimate by weeks or months, of the production of each item that will probably be needed to meet the requirements of the sales program. Such a program has many advantages. It makes possible greater effectiveness in preplanning production, and a more effective preparation for production, a more efficient use of working capital, and relatively smaller inventories of raw materials and work in process. The program enables the company to set up administrative performance standards against which actual results can be checked. A production program permits a more efficient use of plant capacity, and aids in reducing labor turnover. The anticipation of demand usually makes possible prompt deliveries to customers. Such factors contribute directly to lowered costs and increased profits.

The executive committee's recommendation of the sales and production programs does not confer authority for their execution on the heads of these divisions. These programs must be approved usually by the president or executive vice-president. No staff committee, department, or executive should delegate line authority. When these programs are properly approved, copies will probably be forwarded to the budget department and become the basis of budgetary control.

The company in Fig. 6.1 is engaged in multiplant operation. It is probable that each plant management worked out a production program

for its operations. The plant programs were based on the forecasts of sales and production for the product lines that had been allocated to the plant. The plant management probably participated through the general manager in the determination of the production program for the manufacturing division.

The small company, operating a single plant, must face the same basic problems of sales and manufacturing programs. The problems may not be so complex, but they may be quite as difficult, relatively. The top plant and company executives are usually the same individuals in the small concern.

PROBLEMS

1. A company which manufactured rubber and leather footwear secured a large, long-term government contract to produce deep-sea diving dress for the Navy. Delivery was to be made at regular intervals. A separate department was set up for the new production program. Personnel were recruited from among older workers who were employed on continuous production lines. These employees had been skilled operatives prior to introduction of mechanical production equipment. Two models of the new product were to be manufactured, with slight variations between models. Assembly operations involved meticulous manual work, with inspections at numerous stages in the process. Work in process was moved from one work place to the next either by moving it along the work bench, or by placing it on hooks suspended from bar racks, which were then moved by mobile carts. No production standards were set; workers were paid on a flat hourly basis. Since the method of manufacture was obviously different from methods employed for the other products, there was some question in the mind of the production control manager as to what type of control would best apply to the assembly operation.
   (a) Suggest the type of control which could be used for the above situations and explain why.
   (b) What additional information would be required before one could make a definite decision?
2. As the result of his study of organization, the president of a well-known concern which manufactured sporting goods came to the conclusion that the organic functions of production are planning, preparation, scheduling, production, and inspection. With this as a basis, the manufacturing end of the business was broken down into 4 major divisions, each headed by a superintendent who reported to the vice-president in charge of manufacturing. Each of these divisions was broken down into 5 sections headed by planning, preparation, scheduling, production, and inspection supervisors, respectively. The planning supervisor was responsible for all records other than those used currently in production control, and for the origination of various production papers. The preparation supervisor orginated tool manufacturing requisitions for the tool department, placed purchase requisitions

with the purchasing department for materials and supplies needed by the division, and handled other related duties. The scheduling supervisor scheduled all orders for the shop. The production supervisors dispatched orders to the shop, followed them up, and saw that any interferences with production were promptly removed. The inspection supervisor posted to the progress records the production reports he received from the shop, orginated progress reports for the superintendent and coördinate line executives, etc. The 5 supervisors in each division acted as staff assistants to the superintendent. Each of the 4 major divisions was broken down into groups of shop departments, each group headed by a general foreman. This plan of functionalization was followed in the general foreman's as well as in the foreman's office in many of the larger shop departments. It produced excellent results and did not increase overhead expense seriously, except in certain shop departments where its too complete application was attempted. Becoming convinced that it was fundamental to the organization of any productive activity, the president proposed to apply it to all phases of the business, including sales, accounting, engineering, etc.; a start was made with the purchasing department. However, the results were most unsatisfactory, and the attempt was abandoned.

(a) Could these 5 functions be regarded as organic functions of production? How would you classify them as to kind?

(b) What kind of organization elements resulted when this plan of functionization was applied to the factory offices?

(c) Why did it fail in the purchasing department?

3. All rubber tires go through the same stages of manufacture, except for differences in the time and details of processing made necessary by the specifications of particular types or sizes. One of the large producers markets its tires through a chain of service stations; it also manufactures original equipment for automobile manufacturers, and does a good replacement business. Hence its normal volume of production is very heavy. This concern retained a nationally known consultant to install a system of production control which he had publicized widely. It paid him a large fee for his services, and incurred additional heavy expenses because of the necessity of training its employees, etc. A brief description of the way in which the comparison function was performed will indicate the general type of control that the system represented. In the central control office, there was a control board for each department. Cards for each machine in the department were arranged vertically along the left-hand edge of the board, the number, type, and kind of machine being typed on each card. Divisions across the top of the board represented time in days, and in them the actual dates for the particular month were entered. The tires were put through the plant in batches. The production papers prepared for each batch authorized the plant to process the number of tires indicated, showed the operations to be done on each tire, the department in which each operation was to be done, the machine to be used, the time required for each operation, etc. A paper tape was cut to a length representing the time required to complete each operation, as measured by the time scale on the production control board.

This tape was posted horizontally on the control board of the department responsible for the operation, opposite the machine specified. The left end of the tape was put under the scheduled starting date, and the right end under the scheduled finish date; and the information necessary to identify the lot was entered on it. As the operations were completed, the departments reported to the control office which removed the corresponding tape from the departmental control board and checked off the progress of the batch on its records. Thus it could at any time see the status of the lots in any department in relation to scheduled progress. Although this system had been successful and profitable in a number of plants, in less than 2 years this concern had thrown out most of it.

(a) Make a rough sketch of the control board.

(b) What general type of control was applied? Why was the system thrown out?

(c) What general types of control might have given satisfactory results?

(d) The many similar cases which have occurred have led some executives to regard scientific management as theoretical. Should scientific management be charged with this failure? Where should the responsibility be placed? Should calling in consultants be avoided by management? Why or why not?

CHAPTER 16 •

• Production Control with Intermittent Manufacturing

The Application of Control Fundamentals to Production

THE idea has been advanced, in previous chapters, that there are certain organic functions into which control may be broken down, in any industry under any conditions. These functions were listed as routine planning, scheduling, preparation, dispatching, direction, supervision, comparison, and corrective action. Direction, supervision, and corrective action are primarily line functions of control. The others are assignable to staff in a much greater degree, for reasons that have been discussed previously. This concept is an aid in the analysis of any control problem, whether it relates to production or to some other activity. The concept will be applied, in this chapter, to the control of production in a concern making a standard assembled product under conditions of highly intermittent manufacturing. The following chapter will deal with the control problem under conditions of highly continuous manufacturing. The discussions will be confined to assembly industries to gain a clearer understanding of the nature and requirements of the basic control functions. Such industries usually present a more complex control problem than do process industries. These functions usually are performed in the approximate order in which they have been stated above. This is due to the complementary relations that must exist between them. This order accordingly establishes the basis of control procedure.

The Production Control Organization

The first part of this chapter will be devoted to the problems of the central plant production control department, under conditions of intermittent manufacturing. These problems concern largely the interdepartmental coördination of production orders. The work of the department

falls chiefly in the field of major operative staff management, in consequence. The department may also receive information from other staff groups in the plant organization. This information reports other aspects of plant operations, such as quality performance, labor utilization, cost and expense performance, etc. It may be consolidated and summarized by plant divisions and departments. It may be set up in comparison with performance standards for the activities reported. This gives the plant manager a long-range picture of the results that are being accomplished by the principal plant organizations under his command. The manager is in a position to determine the extent to which his immediate subordinates have discharged their responsibilities for results. This phase of the control department's work falls in the field of administrative control at the plant level.

The control department, that was described by F. W. Taylor, exercised many personnel, cost, standards, and other technical staff functions.[1] The distinction between technical and coördinative staff functions was not recognized. The dangers involved in placing a technical staff function in a secondary position, under a staff control group, were naturally not seen. The central plant control department, in a modern plant, is usually relieved of those functions and duties that do not pertain directly to the staff control of production. Thus, in a plant engaged in intermittent manufacturing, its duties may include the analysis of orders and the approval of delivery promises, the planning, scheduling, and routing of orders, the origination of various production papers such as material requisitions and production orders, the placing and follow-up of tool orders, the dispatching of work, the keeping of progress records, etc. This department may coördinate information from technical staff departments, as indicated above, and act as an information center. It should not perform any functions, however, that are properly assignable to a technical staff department. The general nature of the central plant control department's work was discussed in connection with Fig. 15.5.

The production control responsibilities of the shop department manager, or foreman, will be discussed briefly in the last part of the chapter. The tendency in modern management is toward decentralization. The maximum degree that is practicable depends on the manufacturing problem of the particular plant. The department manager becomes increasingly responsible for the proper performance of all control functions with increasing managerial delegation and decentralization. He becomes increasingly accountable for results, which is one objective

[1] Frederick W. Taylor, *Shop Management*, Harper & Brothers, 1911, p. 111.

of decentralization. The manager is assisted in the discharge of this responsibility by his line and staff subordinates, and such supporting staff services as are available to him.

The Production Program

The primary service objectives of a business organization are the starting point for the work of planning, organizing, and controlling its activities. These objectives may be short range, intermediate, or long range. The objectives of the production line organization, at the operative level, are short range. It is the responsibility of the shop to ship what the customer wants when he wants it. The customer usually wants delivery of his order in much less than a year from its receipt. The exception may be the concern that manufactures very large installations to the customer's specifications. A large turbogenerator or an observatory telescope may require more than a year for its manufacture. Production control is usually concerned with the short-range coördination of shop operations, for the above reasons.

The production program is a practical statement of certain primary service objectives of the production division. It is a statement of the quantities of each product to be manufactured during each month or other division of the period. This period is usually less than a year, as indicated above. The production program is derived from the sales program, but it is not identical with it. The company may produce finished parts or product to stock, for one reason. The program may be revised monthly, as we progress through the year, to conform to revisions of our business forecasts and sales program. Figure 16.1 shows part of a production program for a large machine-tool manufacturing plant.

The production control department will probably break down the program to show the quantity of each component part of each product that must be produced. The program may then be analyzed to show the amount and kind of each raw material that will be required to make the parts program, and the approximate time when it will be needed. Procurement and parts fabrication must lead assembly and shipment, obviously. The nature and use of lead time will be seen when we look at the problem of scheduling.

Coördination of Sales, Plant Capacity, and Deliveries

Concerns engaged in highly intermittent manufacturing often find it quite a problem to meet promised delivery dates, particularly during periods of prosperity. Delivery by a given date is often a condition

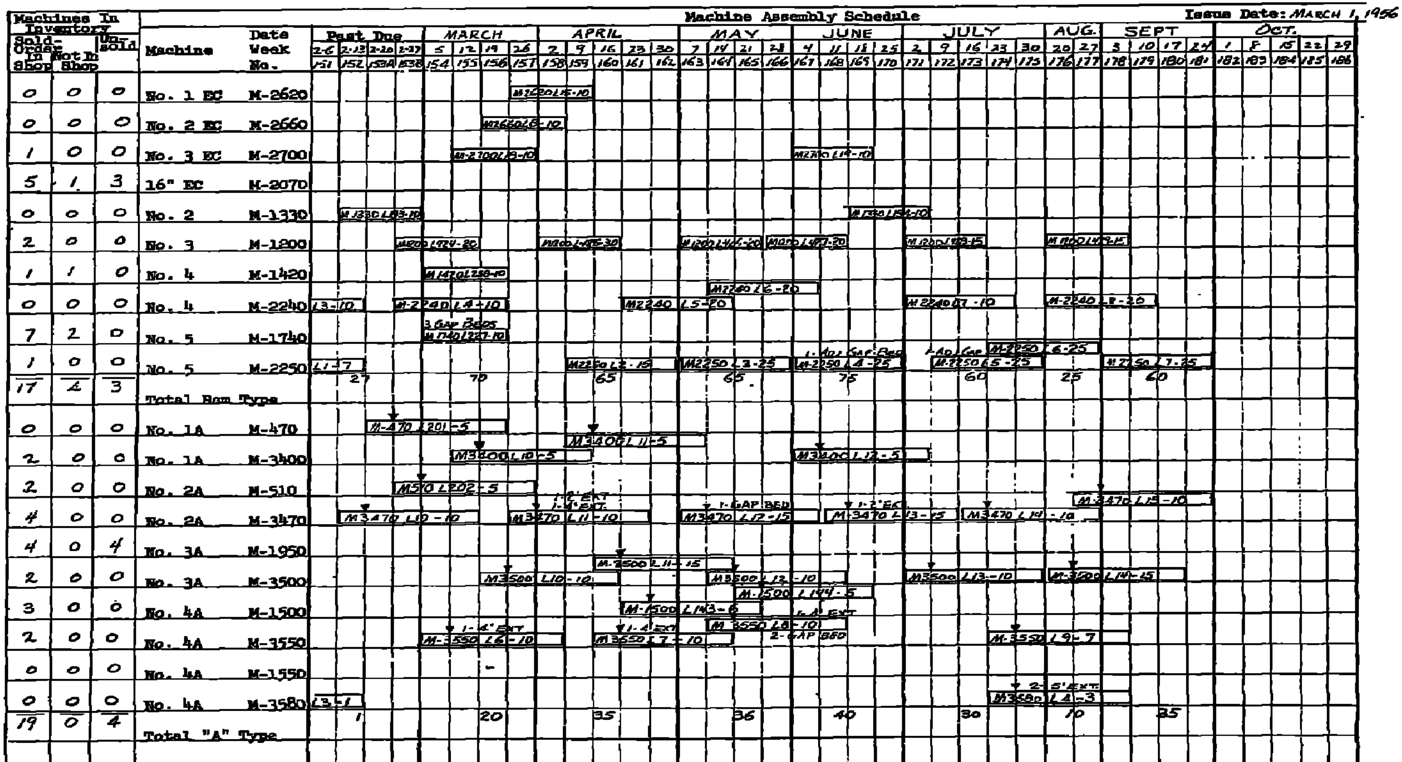


Fig. 16.1. Part of a Production Program of a Machine-Tool Manufacturer. (Courtesy, The Warner & Swazey Company.)

imposed by the customer before he will place his order. Unless there is some control, the salesman may make any delivery promise that is necessary to get the business, without regard for the factory's ability to meet it. The customer may be lost if the shipment is not made when promised. If the plant is running near its capacity, it may be necessary to work overtime, rearrange schedules, or take other steps that run up costs, in order to ship on time. The problem of customer delivery promises is often present during periods of depression because the concern may reduce its working hours and working force, take machines out of production, and in other ways reduce its productive capacity to conform to the decreased sales volume. The problem is much less serious, however, because of the abundant idle capacity.

Some companies have placed the coördination of available plant capacity and customer promise dates in the hands of the production control department. One concern reduces incoming orders for a miscellaneous variety of products to a tonnage basis. Analysis of its sales and production records has shown the number of tons of orders that represents a week's working capacity for the plant. The production control department charges incoming orders against the last open week, up to approximately 80 percent of its capacity. The sales department is then asked to accept no orders for delivery before the end of that week without consulting the factory. The unapportioned 20 percent is a margin of safety which allows it to handle rush orders that really require preferential treatment; if this is not needed, later deliveries can usually be pulled ahead. There are more refined methods for coördinating delivery promises with available plant capacity. One that is well known uses the Gantt Load Chart.[2]

Authority for the Manufacture of the Product

Manufacturing activities must be initiated before an order can be put into production. This can result only from a release or delegation of authority by higher line authority. The principal source of this authority in the manufacturing division is the vice-president in charge of manufacturing. The instruments by which it may be conveyed are: (1) the sales memorandum, (2) the production program, and (3) the manufacturing requisition. The instrument and its use will differ considerably between plants.

In highly intermittent concerns which manufacture largely to the customer's specification, a factory copy of the sales memorandum covering the order may be sent directly by the sales office to the plant

[2] See Wallace Clark, *The Gantt Chart*, The Ronald Press Company, 1922.

office. It is merely a request to make and ship certain quantities of a certain product to the particular customer at a specified time. This is often true of companies making capital goods. The sales memorandum becomes a release of authority to produce only when it is approved for the plant manager by someone authorized to do so. This may be the production control manager. The vice-president in charge of sales cannot give commands to the production division, because the manufacturing vice-president is accountable for its operations.

The production program is highly important in continuous manufacturing. It may be important also in intermittent manufacturing, but it does not usually enter so directly into production control. The production program is frequently broken down into assembly and parts programs. The control department may write manufacturing and production orders up to the limits of the quantities indicated, taking into account inventories of the particular products or parts on hand.

A manufacturing requisition such as that in Fig. 16.2 may be used by plants which manufacture finished parts, subassemblies, or finished products to stock. It is frequently more economical to manufacture intermittently to stock, when parts and products are well standardized but unit volume is low. For example, when the inventory of a manufactured item falls to the reorder point, as shown by its stock record, a manufacturing requisition is made out for the standard manufacturing quantity. This quantity is usually the most economical to make. When approved for the plant manager by production control, the requisition authorizes the production of this amount.

Types of Factory Orders

The control of action depends on the control of the authority to act. This is one reason why the dispatching function is always important, particularly in intermittent manufacturing. Orders are clerical instruments designed to facilitate and control the release of authority; in consequence, they are important factors in control.[3]

The intermittent manufacture of an assembled product breaks down into the manufacture of its basic parts and the various subassemblies that compose it. The manufacture of each subassembly in turn breaks

[3] We have distinguished previously between technical orders and operational orders. The first authorizes the use of designated means and methods for accomplishing some undertaking, or kind of undertaking, in accordance with a plan. The undertaking could be the manufacture of a standard quantity of some part. The second authorizes action that is required for the accomplishment of the particular undertaking that has been designated on the order. The undertaking could be the manufacture of a specified quantity of the part for delivery to assembly on a certain date.

down into the manufacture of the various parts that enter into it, and the work of assembling them. The work of manufacturing each part breaks down into various operations. The quantity of each part that is necessary will differ, depending on the number required to assemble

ISSUED BY	DATE	ORDER No.
OLP	6-29-56	6C2326-09

AMOUNT	DESCRIPTION
20	36 x 36 Pan Deck

FACTORY	SUPPLY	SETUP WANTED		TYPE	CLASS
B-6					TR

INVESTMENT	INVESTMENT	CONSUMPTION			
		19		19	
		F.	S.	F.	S.

DATE	MONTH	AMOUNT	L.	B.	M.	F. C.	PER
8/15/56	08	20					

Stock Program # 133

CHECKED BY	O.K. FOR RECORD	VARIATION	COST POSTED
Izzie			

Fig. 16.2. A Manufacturing Requisition. (Courtesy, The Jeffrey Mfg. Co.)

each unit of finished product, the inventory to be carried, etc. One thousand units of part A and 2000 units of Part B may be required to assemble 1000 units of finished product. The order of the movement and processing of each distinct quantity must be controlled so that the particular parts will arrive at the various assembly points at the proper time. The general nature of this problem is illustrated in Figs. 15.1 and 16.7.

It is evident that many different types of factory orders are needed in the control of such a complex situation. The most common general types are: (1) manufacturing orders, (2) expense orders, and (3) asset orders.

Production control is concerned principally with the manufacturing orders. A manufacturing order authorizes the manufacture of a given number of units of finished product. As we have seen, it may originate from either a production program, a sales memorandum, or a manufacturing requisition. The manufacturing order usually originates in the office of the plant manager. It may require the approval of the general manager or the manufacturing vice-president in some instances. Under the authority of the manufacturing order, (a) production orders, (b) production suborders, (c) replacement orders, (d) rush orders, and (e) repair orders may be made out.

A production order authorizes the manufacture of a given quantity of a particular component part or subassembly. The quantity ordered may not correspond to the quantity of finished product, for reasons previously stated. Such an order usually originates in the production control department. In highly intermittent manufacturing, its functions are sometimes combined with those of an operation sheet, or plan of work, to eliminate an extra form. As a rule, copies of the production order are sent to each department concerned, as advance notification and authorization.

The production suborder is a device which authorizes a given operation to be done on a given quantity of a particular part, under the authority of a production order. A distinct suborder form is seldom used. In intermittent manufacturing, production control is usually decentralized, and the foreman's office may issue to a workman a job ticket covering a given operation. This authorizes him to perform the operation and to receive payment therefor, if his work is satisfactory. Under these circumstances, the job ticket is being used as a suborder.

Replacement orders authorize the processing of a quantity sufficient to replace the amount scrapped on a production order. Such orders are issued only when the amount of scrap has been considerably larger than anticipated and the shortage must be made up at once. Most plants engaged in intermittent manufacturing occasionally issue rush orders giving priority to a particular production order. However, their use must be closely restricted because there is usually a tendency to abuse them. Replacement and rush orders are likely to disrupt the normal routine of the shop. Such orders should be issued only when absolutely neces-

sary. Repair orders, issued from time to time, authorize the manufacture of repair parts. In most cases they are required by the parts and service division which must service obsolete models. The unit costs of such orders may be very high because of the small quantities that are run.

Expense and asset orders do not affect production control directly, but they are vitally important to efficient industrial management. Expense orders are issued for work in connection with the repair and maintenance of plant and equipment, and any other work of a similar nature. Asset orders are issued to authorize work which increases the capital value of the plant.

Routine Planning for Production

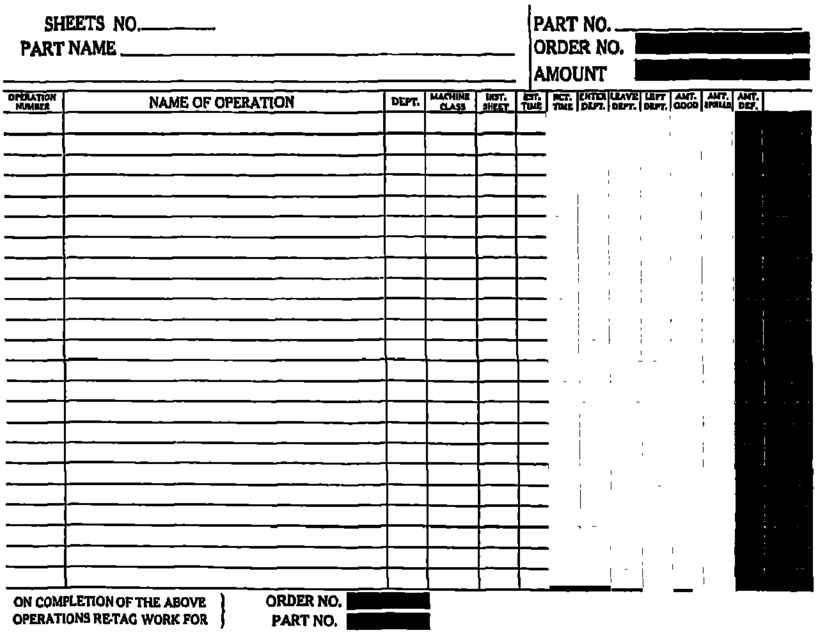
Routine planning has been defined previously as the secondary, or routine, determination of what should be done, how and where it should be done, and who should be responsible. In connection with production control, it has to do largely with the reproduction of certain phases of our product and process plans in a form that will facilitate their execution by the line organization, and the control of execution. This information would probably be obtained principally, in the organization shown in Fig. 15.5, from the product engineering and industrial engineering departments.[4] Additional information would be required from other line and technical staff executives. There is a basic similarity between the production functions and factors that must be coördinated under conditions of itermittent manufacturing. There is a marked similarity, accordingly, in the items of information that are required for production control purposes by different concerns. The more common items are:

A. General product information
   1. Name and description of the product or component part
   2. Its product symbol or part number
   3. The material required
      a. Description, symbol, and specification number
      b. The quantity required per unit of product
   4. The model usage of the part
      a. Models using it for assembly purposes
      b. The number of pieces required per unit of model
   5. The standard manufacturing quantity

B. Information relating to operations on the part, and certain physical factors that enter directly into their performance

[4] It was noted during the discussion of the production organization, that the executive who has staff responsibility for process planning may have various titles in American industry. Some of them are industrial engineer, process engineer, manufacturing methods manager, and manufacturing engineer. An older title, master mechanic, is still found occasionally.

1. The operation numbers which establish the sequence of operations
2. A brief description of the operation
3. The department in which each operation is to be done
4. The class of machine to be used for each operation
5. The tools and equipment required for each operation, such as jigs, fixtures, gauges, dies, etc., with reference as to whether they are standard or nonstandard
6. The unit process time required for each operation


SHEETS NO.______ PART NO.______
PART NAME ______ ORDER NO.
AMOUNT

OPERATION NUMBER	NAME OF OPERATION	DEPT.	MACHINE CLASS	INST. SHEET	EST. TIME	ACT. TIME	ENTER DEPT.	LEAVE DEPT.	LEFT DEPT.	AMT. GOOD	AMT. SPOILED	AMT. DEF.

ON COMPLETION OF THE ABOVE OPERATIONS RE-TAG WORK FOR ORDER NO. PART NO.

Fig. 16.3. A Master Plan of Work, or Operation Layout Sheet

a. The time required to set up and adjust the machine before the order can be run
b. The machine time per piece, or the rate of production that can be maintained subsequently

7. The job classification of each operation and the number of operatives used normally for the standard quantity of product

This information is entered on an appropriate form that may be called a master plan of work, an operation layout sheet, or by some similar name, depending on the particular concern. Such a form is merely a record for collecting product and manufacturing information in a form that will facilitate transcription to the necessary production papers. Examples have been shown in Figs. 9.7 and 16.3. This form may be originated by the industrial engineering department, on receipt of an

engineering release notice and accompanying product design information from the chief engineer's office. Most of the information on the form has to do with manufacturing methods and standards. Process planning depends on and follows product planning. The industrial engineer's office may act as the collection agency for production planning information for these reasons.

The production control department may receive the original copy of the plan of work for its files. It reproduces the information on whatever forms are necessary for use by the line in producing the product, or for production control purposes. Production control, as a result, relieves engineering departments of the routine work of reproducing product or process information. A substantial change in product or process is usually regarded as an engineering change. It should be authorized by an engineering change order, or its equivalent. Any such change is not routine: it requires some original planning of product or process. The control of the release of manufacturing information to primary line departments is usually necessary for the control of production, however. This is one reason why product and process information should be released to the line organization through the production control office.

The master plan of work may also be considered a record of certain manufacturing standards for a standard part. The materials symbol and specification number, the machine class symbol, the job classification symbol, and the tool lists represent certain standards of condition. The operation lists and descriptions represent standards of operative procedure. These lists are tied in with standards of organization structure through the department number or symbol. The rate of materials and parts usage, and the unit process times, represent standards of performance. These standards aid in performance of the preparation and scheduling functions, as well as comparison. The general nature of these standards was discussed in Chapter 3.

The clerical instruments to which the information on the master plan of work must be transferred vary with the needs for production and control under the particular manufacturing conditions. The name and number of the part will enable the requisitioning of blueprints of it, if necessary. The more common production papers originated by the planning section of the control department are operation tickets, material requisitions, route sheets, route tags, and tool lists. This section may also write various manufacturing and production orders under direction, for approval by a higher authority. Operation tickets are sometimes called work orders, job tickets, or time tickets. These tickets authorize the

workman to do a given operation and to receive pay therefor. These may originate in the central control department when they take the place of a production suborder. These tickets originate in the office of the department foreman when control is decentralized under conditions of intermittent manufacturing. Operation tickets may also be used in costing the product, and in payroll computations. So far as production control is concerned, they are usually important because they enable the progress of the work to be followed through the shop. A material requisition is a written order on the storeroom to issue a certain kind and quantity of material for use on a given order. It may be written on a machine tabulating card. Since is carries the order number to which the material is to be charged, as well as the material symbol, it may enter into costing, as well as into inventory control. The kind and amounts of materials to be carried in inventories are determined from requirements that are indicated by an engineering bill of materials for each product. Such a bill usually lists the component parts of the product. It indicates the kind of material from which each part is made, and the amount required per part, including an allowance for necessary waste.

For example, a master deck of I.B.M. cards may be produced for each item on a bill of materials, such as the one shown in Fig. 16.4a. A parts requirement list, such as the one shown in Fig. 16.4b may be reproduced from this deck. "Condition 1" in Fig. 16.4b indicates the number of parts that are ordered against program requirements; "Condition 2" indicates stock parts that are ordered as a reorder point is reached for each part; "Condition 3" indicates special parts to customer order only. Copies of such bills may be received by production control from the chief engineer's office.

Route tags are used frequently under conditions of intermittent manufacturing. They are attached to a piece or lot of work to identify it and direct its movement through the shop. They show the information necessary to identify the orders and the part, and the list of operations and departments through which it moves. They are usually made out by the planning section and together with the material requisition, are subsequently dispatched to the storeroom or to the department performing the first operation. In some concerns, the kinds and quantities of tools and equipment required for each operation on an order are listed on a form to aid in tool preparation. Other concerns duplicate the master plan by the ditto process or some other method of duplication. The ditto copies are used as production suborders. They eliminate the need for the origination of job tickets or tool lists by the production control office.

6-5M-7-55

PRODUCTION LIST

P. L. SHEET No. LSV-4-3

Connecting Rod Assembly

ENG. No.

M. O. No.

DATE

Col. "A" - For Production

NO. REQ'D	MAT'L	ASSEMBLY NO. LSV-4-3 NAMES OF PARTS	PATT NO. AND DETAIL NO.	ITEM	REMARKS
1	SF	Master connecting rod	LSV-4-3A	1	[redacted]
1	SF	Articulated rod	LSV-4-2B	2	
1	SC	Master conn. rod cap	LSV-4-3B	3	
2	S	Piston pin	LSV-4-L	4	
1	S	Articulated rod pin	LSV-4-D	5	
2	Cmrl	Conn. rod bearing shell	LSV-4-N	6	
1	Bz	Articulated rod bushing	LSV-4-F	7	
3	S	Conn. rod dowell	LS-4-L	8	
6	S	Piston pin bolt washer	LSV-4-1D	9	
6	S	Piston pin bolt	LSV-4-1C	10	
4	S	Piston pin bolt lock	LSV-4-K	11	
6	S	Drake lock nut NF 1/2	CSA-344	12	
4	S	Bushing dowel 5/16 x 1" Lg.	CSA-86	13	
2	S	Conn. rod cap dowel	GMW-43-E	14	
2	S/Asb	Rod and Cap shim	LSV-4-G	15	
2	S	Art. rod pin bolt lock	LSV-4-J	16	
2	S	Conn. rod check Vl. spring	LT-4-2G	17	
2	S	Conn. rod check valve	LS-4-R	18	
2	S	Conn. rod check Vl. sleeve	LS-4-Q	19	
2	S	Conn. rod check Vl. plug	LS-4-P	20	
4	S	Castle nut NF 1-1/2	CSA-308-1	21	
4	S	Cotter pin 5/16 x 2-3/4 Lg.	CSA-126	22	
4	S	Conn. rod stud	LSV-4-H	23	
			7-30-56		

Fig. 16.4a. An Engineering Bill of Materials. (Courtesy, The Cooper-Bessemer Corporation.)

The Route Sheet: The route sheet, in the original form shown in Fig. 16.5, was a device for recording the progress of an order through the various departments and operations that entered into its processing. It was used chiefly as an aid in dispatching operations. This form is seldom found today as a separate control instrument. It is more common practice to use a duplicated copy of the operation layout sheet, or plan of work. Either of the forms shown in Figs. 9.7 and 16.3 could be used for following the progress of an order. These could be used also for dispatching production papers authorizing the operations that are yet to be performed on the order.

THE WARNER & SWASEY COMPANY
MACHINE AND LOT GROSS REQUIREMENT REPORT

MONTH YEAR PAGE NO

PART NUMBER	PART NAME	ORDER DATE	UNIT NUMBER	ASM. NO	LOT NO.	ASSEMBLY NUMBER	▲	PART STOCK DATE	COND. # 1	COND # 2	COND # 3	24
621 1002	PIN	155	1208		410			150		15		
523 1012	SCREW	162	1403		137			153		5		
		154	1413		160			155		10		
538 1010	SCREW	154	1207		228			155		15		
540 1033	KEYS	148	2710		23			157	10			
540 1044	PINION	151	3455		76			153	15			
		152	3505		54			154	10			
540 1045	WASHER	163	1245		288			156		15		
		153	1298		224			155		15		
540 1046	IDLER GEAR	151	3478		77			153	15			
		152	3508		54			154	10			
540 1047	KEY SHAFT	147	3455		76			153	15			
		147	3478		77			153	15			
		148	3505		54			154	10			
		148	3508		54			154	10			
540 1048	DOUBLE GEAR	149	3455		76			153	15			
		149	3478		77			153	15			
		150	3505		54			154	10			
		150	3508		54			154	10			
540 1049	GEAR SHAFT	150	3455		76			153	15			
		150	3478		77			153	15			
		151	3505		54			154	10			
		151	3508		54			154	10			
540 1050	SLIDING GEAR	149	3455		76			153	15			
		149	3478		77			153	15			
		150	3505		54			154	10			
		150	3508		54			154	10			
540 1051	SLIDING GEAR	149	3455		76			153	15			
		150	3508		54			154	10			
540 1052	DOUBLE GEAR	150	3478		77			153	15			
		151	3508		54			154	10			
540 1058	REVERSE ROD	151	3478		77			153	15			
		152	3508		54			154	10			
540 1059	PINION SHAFT	150	3478		77			153	15			

Fig. 16.4b. A Parts Requirement List. (Courtesy, The Warner & Swazey Company.)

Economy in the Performance of Office Functions

Certain functions must be performed in the control of production. Inasmuch as they are managerial functions, the instruments used are chiefly clerical. Certain general forms have been found useful in a wide variety

of control situations for a particular type of industry and manufacturing conditions. They have become somewhat typical of these situations. The design of these forms will vary greatly between concerns, however; not all of them will be needed in every instance.

The cost of preparing, handling, and maintaining these forms is overhead expense. There are three principal ways of holding down the cost of clerical operations in the control department. (1) Orders, records, and other clerical instruments may be designed to perform as many functions as possible. The use of the master plan as a progress control device is an example. (2) Information may be duplicated directly from production

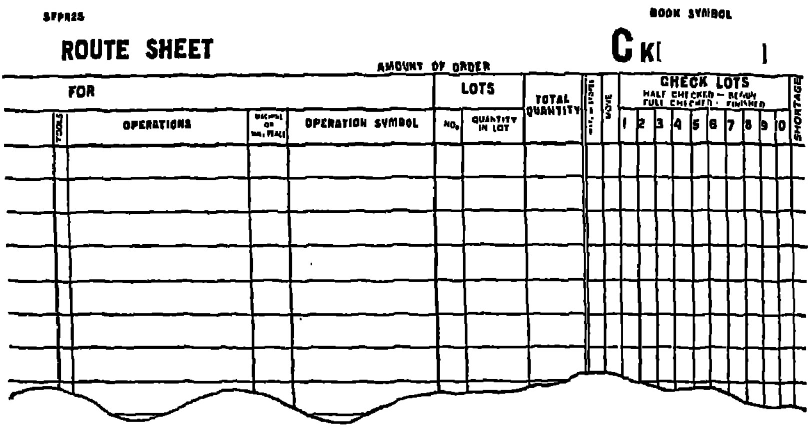


Fig. 16.5. An Early Example of a Route Sheet. (Courtesy, Mr. John A Fisher.)

planning records. There are a number of ways in which this may be done. The ditto system is one. The master plan of work is a ditto form, and the production control information for a part or product is typed on the form with a ditto ribbon. The duplicated plan, or operation list, can be used as a progress control device. Shipping tags, move tags, and most of the required production papers also can be duplicated from the original master plan, provided that is is designed properly. The master copy of the operation sheet, in Fig. 16.3, is printed on vellum or a good grade of bond paper. A reversed sheet of carbon is placed in back, when the production data for a particular part are typed on it. This makes an excellent negative. When an order is to be produced, the master copy is run through an ozalid machine or some other office blueprinting device, to get the required number of copies. One copy may be sent to the scheduling unit where the schedule for the order is entered. Much of the information on the duplicated sheet is needed by the shop office for the control of its work on

the order. A copy may be sent, in consequence, to the foreman of each department that works on it. Its receipt may authorize the foreman to do his particular work. The sheet now aids in the performance of two additional functions, dispatching and direction; its primary functions have been combined with those of a shop copy of the production order and those of process instructions. Methods similar to this may be found in small plants that have a small number of departments. Some concerns use I.B.M. or Remington-Rand tabulating equipment. The master plan, or operation sheet, is reproduced in such cases from punched cards. It is used chiefly for progress control purposes. It may be practicable to use such equipment, when it is needed for accounting and other clerical purposes. This is more likely to be the case in large manufacturing plants. The general objective is the same, regardless of the method: a reduction of clerical expense through a transfer of clerical knowledge and effort from the clerk to the office machine. (3) The control system may be analyzed for economy of procedure, to the end that only the necessary clerical functions will be performed in the simplest, most effective manner. A simple, reasonably sound plan, carried out consistently and intelligently, is likely to be more effective than one that is extremely complicated. This is usually true, even though the latter plan may be more correct theoretically.

The Quantity to Produce

The quantity to be processed is an important factor in the economy in manufacturing. The problem varies with the nature of the product, the volume and nature of production, the nature of manufacturing operations, etc. Three general phases of it may be recognized. They have to do with manufacture of (1) the specific quantity ordered by the customer, (2) the economical lot size, and (3) the requirements of a production program.

A manufacturer of large telescopes for observatories can produce them only when and as he receives contracts for them. He must work entirely to the customer's specifications. The company has no assurance when it completes a contract that it will ever be called on again to manufacture another telescope of the same size and design. Obviously, the quantity specified on a production order for a given part must be the number of units of that part required to assemble the telescope.

In the intermittent manufacture of semistandard or standard products, many parts may have been standardized for use on one or more products. There is a repeated but intermittent demand for these products. It may be possible and economical to anticipate this demand by the use of economical lots or ordering quantities. Figure 16.6 shows dies being set in

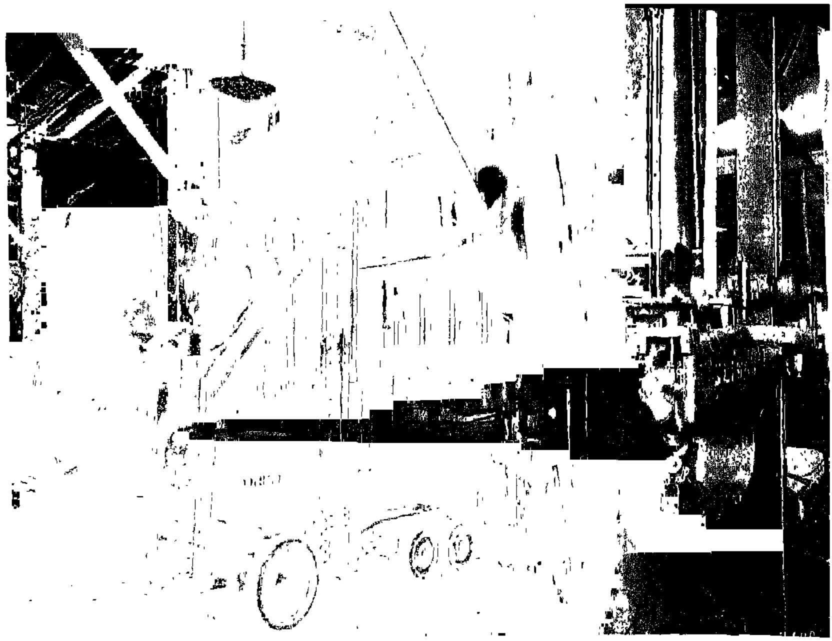


Fig. 16.6. Dies Being Removed from a Sheet-Metal Press, with the Aid of a Heavy-Duty Truck. (Courtesy, The Baker-Raulang Co.)

a sheet-metal press. In such presses as this, various blanking, piercing, drawing, bending, and forming operations will be done on metal sheets of the proper gauge and specifications. The dies are quite heavy. The upper and lower dies must be lined up accurately and fastened securely in place. The work will not meet the quality standards otherwise. The time required to make a machine ready for production is usually called "setup" time, and may vary from a few minutes to a week or more in the case of heavy machines. If 25 machine operations are required to make a part, 25 setups will usually be necessary. The operatives must of course be paid for the time that they spend on this work. There are, in addition, many other preparatory costs of manufacturing that must be met. If a concern were to make a single piece, the cost might be prohibitive relative to the price it could get in competition with similar standard products. The unit preparation cost probably would be negligible, if it made a million pieces. On the other hand, the more demand is anticipated, the longer will the finished parts remain in stores. Interest charges, storage charges, and the danger of depreciation and obsolescence will be greater accordingly. As manufacturing quantities increase, with a limited and intermittent demand, these charges begin to overbalance the savings resulting from decreasing unit preparation costs. The rate of turnover of an important part of our working capital decreases. Somewhere between the million pieces and the single piece there is the quantity that is most profitable to

manufacture. This is shown on the finished stock inventory records. It is this quantity which is ordered on the manufacturing requisition when the stock of the part falls to the reorder point. It is evident that economic ordering quantities affect inventory control, as well as the economy of production and its control.[5] The determination of economic ordering quantities will be discussed later, in connection with inventory planning and control. It is sufficient here to note that the range of use of such quantities is limited. It extends, on the scale in Fig. 15.3, from the intermittent manufacture of semistandard parts to the semicontinuous manufacture of standard parts. The limits of this range cannot be determined exactly; they are a matter of judgment.

In the case of the continuous manufacture of standardized products, the picture changes again. Production is usually authorized by means of monthly production programs and weekly plant schedules. It may be coördinated closely with forecast sales. The volume is sufficient to warrant laying out the plant for straight-line production and assembly. Manufacturing is continuous at the rate called for by the current program and schedules.

Scheduling

Scheduling has been defined above as the function of determining when or at what rate each stage in the execution of a program or project shall be completed. With continuous manufacturing and a flow control of production, scheduling has to do with the determination of the rate of production that must be maintained. With a decentralized order control of production, scheduling has to do with the determination of the calendar dates on which the order should enter and leave each department that is responsible for certain operations in its processing. With centralized control, the central control department may decide when each operation on each order should start and finish. It is usually more effective to decentralize control with intermittent manufacturing. The immediate objectives of scheduling in intermittent manufacturing are: (1) a satisfactory basis for the time coördination of the various line and staff activities that enter into the production of the order, and (2) a performance standard indicating a satisfactory rate of progress for the order through the various stages of its processing.

[5] Inventory control records are sometimes called "balance of stores" records. They facilitate the coördination of the staff function of supply with the use of materials by our primary line departments. They are frequently placed under the production control department, when manufacturing is intermittent, for this reason. The operation of inventory control records should be tied in with purchase procurement operations.

In order to attain these objectives, information concerning the various factors that enter into coördination and progress must be available. The more important items that are usually needed immediately are: (1) a list of the parts and subassemblies that make up the product, (2) the assembly relationships between them, (3) the time required for each assembly operation on each subassembly, (4) the manufacturing time required for each operation on each component part, (5) the proper routing for each part and assembly, (6) the time required for procuring purchased materials for specific parts when these materials are not carried regularly in stock or the available stock has been exhausted by a sudden demand, (7) the quantity to be manufactured, and (8) the relative urgency of the order. The amount of information necessary may vary in particular cases; the above list gives a tangible idea of the kind that is required. Most of this information may be supplied by the planning section. Some of it may be modified on different orders for the same product because of changing conditions. Scheduling must therefore follow routine planning, even in the case of standard products.

It is important that the preliminary work of control be completed in the shortest possible time. It is customary to prepare standard scheduling data for standard products in a form that will permit quick, easy modification with minor changes in conditions. Coördination of action involves two principal factors; time, and the order of performance of the principal phases of the project. *In intermittent manufacturing, therefore, it is necessary to determine the normal relationships between quantitative manufacturing and assembly time requirements, routings, and chronological time objectives.* In scheduling orders, one must work back from the date when delivery should be made to the assembly floor, the shipping floor, or the storeroom, to the date when each part or subassembly should start in production. The time required for the final assembly of the product must be known. Those parts which enter directly into final assembly, and those which will be brought together previously in subassemblies must also be known. The time required to complete the final assembly, each subassembly, and each manufactured part, must be determined. Such manufacturing time is conditioned by the standard quantity of each part that is normally ordered. If these time requirements are entered on a work-time scale in accordance with assembly relationships the result will be a diagram similar to the one shown in Fig. 16.7. This deals with the manufacture of a standard assembled product, No. 121, which has a repetitive

but quite limited demand.[6] It is normally assembled in lots of 50. Parts 1, 2, 4, 6, 10, and 11 are used only on this model. Only the quantity of each part that is required for the order will be made, because of the limited demand. Parts 3, 5, 7, 8, and 9 are used on other models as well. In their case, the volume is sufficient to warrant manufacturing them to stock. They are drawn normally from finished parts stores on requisition when an

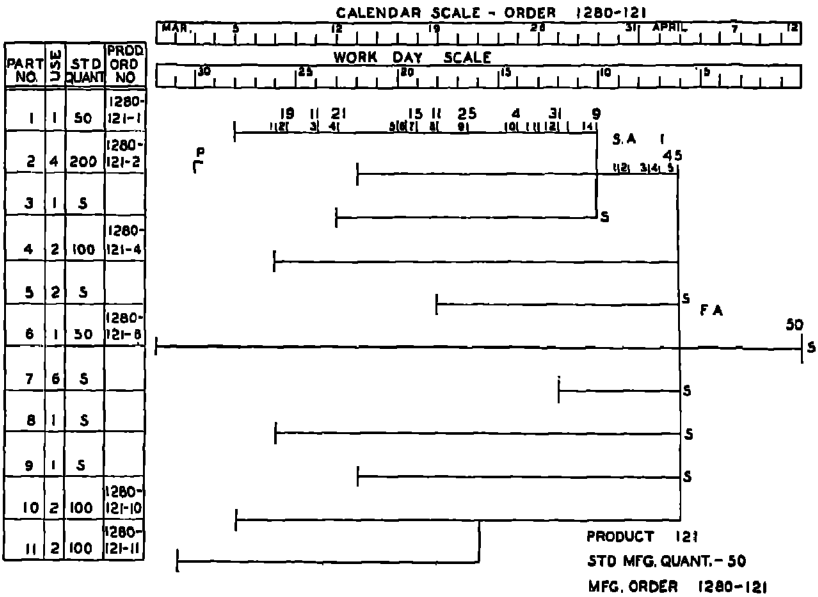


Fig. 16.7. A Manufacturing Assembly Design

order is to be assembled. If this cannot be done because the supply on hand has been depleted, a production order for the particular order will be prepared and scheduled. All three methods of determining manufacturing quantities may be used, in this case. For certain parts, the quantity is determined by the order. For stock parts, it may be determined by the economical anticipation of an intermittent, repetitive demand. Ordering such parts may be controlled by balance of stores records, using stock limits. Furthermore, the standard lot of 50 finished units may be modified to meet the production program.

It is clear from Fig. 16.7 that the time when a quantity of parts will be

[6] The diagram in Fig. 16.7 is a graphic representation of assembly-time relationships. They could also be set up statistically. Many concerns prefer to do so. They feel that a statistical representation can be modified quickly and with less expense to accommodate changes in product or process.

needed for assembly is quite as important as its production time, in determining when the part should be put into production. For example, part 10 requires 22 working days for its production, part 11 requires only 15. The latter should start production approximately 31 working days before completion of the final assembly of the order, but part 10 does not need to start until approximately 28 days. This also makes clear why the delivery of small parts to the proper assembly floor on schedule is quite as important as the delivery of the largest piece. The number of days before shipment of the order is often called "lead time."

The analysis of manufacturing relationships can be carried down to a given operation on a given part in a given department; this is frequently desirable in intermittent manufacturing. In Fig. 16.7 the assembly operations for subassembly 1 have been laid out, on the basis of the workday scale shown, beginning with the last operation. The same thing has been done for part. 1. The master operation sheets supply the proper department numbers which have been entered above the corresponding operations, thereby indicating the routing. Thus operations 5, 6, and 7, on part 1 are done in Department 15. If 50 pieces are ordered, they should be shipped to Department 11 approximately 19 days before the completion of the final assembly.

In laying out the time for specific operations, one should remember that manufacturing time usually includes three elements: setup time, process time, and a necessary amount of nonproductive time that is called variously "dead time," "float time," "move time," etc. This last includes the time when work is moving between departments, waiting in the department to be moved to the next machine or to the inspector, etc. The time required to land a piece of work in a machine, as in Fig. 11.1, is called "preparation" or "handling" time. It is a part of the process time. It is included in the time-study standards. The time that is needed to move the lot of castings in Fig. 11.3 to and from the drill press is a part of the necessary "float" or "dead" time. This may constitute from 40 to 60 percent of the total manufacturing time for a part or assembly. Such float time cannot be neglected, obviously, in determining scheduling relationships.

These general relationships establish the basis of coördination. A schedule for a specific order requires their conversion from quantitative to chronological time values. Figure 16.7 is based on the assumption that production of a lot of 50 units of product 121 has been authorized under Manufacturing Order 1280. (The product number is affixed to the manu-

facturing order number for identification purposes.) The lot must be completed on April 12. A calendar scale has been drawn above the work-day scale in the same time units as the latter. Five units on the scale represent a calendar week, because the plant works a five-day week. The chart now shows approximately when each operation on each part or assembly should start and finish, assuming normal progress. It appears that Production Order 1280-121-1 for part 1 should leave Department 15 on March 18 and go to Department 11.

The dates of starting and completing each operation on each part or assembly, or with decentralized control, the date on which the order should leave each department, should be entered on some record. It should aid in dispatching, in performing the comparison function, and in conveying the schedule to each shop department office. We shall assume that this record is the master plan of work and operation sheet shown in Fig. 16.3.

The above schedules have been based on facts, past production records, time studies, or opinions of experienced executives. Why then cannot orders be released to the shop in accordance with these schedules? This would be unwise because they indicate good progress for the average order for the particular part or assembly under normal conditions. The actual progress of a specific order may depart from the average. For example, Order 1280-121-1 is scheduled to arrive in Department 15 for Operation 5 on March 12th. The requisite machine capacity may not be available on this date. The order must be held up or some other order must be set aside, in such case. There may be an interference with production, confusion, and loss of coördination, as a result. For this reason the availability of capacity and other physical factors in performance should be checked before the order is released. It will be seen that there are two phases of scheduling, preliminary and final. When conditions have been checked and the schedule has been modified accordingly, there is reasonable assurance that it will be practicable.

The Preparation Function

Preparation is the function of assuring the presence of the various factors in performance when and where they are needed, and in the kind, degree, and extent necessary. Effective, economical production is impossible unless employees are provided with the proper materials, tools, and other performance factors. Some things, such as work benches, always remain in a particular location. No checkup of their availability and condition is required except at relatively long intervals. But it may be neces-

sary to assure the presence of other factors, such as special tools, each time an order for a particular part or assembly is run. The absence of such factors at the time when the particular operation is begun inevitably causes a holdup in production. The principal objectives of preparation, therefore, are effectiveness in performance and the avoidance of interferences in so far as the latter result from neglect in providing the proper factors. It is not the responsibility of preparation to organize for production. Organizing is a basic management function. It has to do with the prior creation of the basic conditions that underlie effective, economical performance. Preparation is not responsible for the provision of the specific performance factors that may be required for a given project or program. Such provision is usually the responsibility of the technical staff department that plans or facilitates the use of a particular factor. Our supply division, for example, is usually responsible for inventory planning and the provision of the right materials, where and when required. Preparation is responsible merely for coördinating the line organization's need for a particular factor with the work of the particular staff organization that must supply it. Preparation must anticipate the requirements for the necessary performance factors. It assures a minimum of interference with execution by so doing.

In intermittent manufacturing, the principal factors that require preparation are usually man power, tools, materials, and machine capacity. When the preliminary scheduling has been completed, the scheduling section must turn over the various production papers to an individual or group that is responsible for checking the availability of these factors, and for assuring their presence when and where they are needed. For example, the tools required for the different operations on a part may be classified roughly as standard, nonstandard, and special. Special tools must be made either by an outside jobbing tool and die shop, or by the company's own tool department. In the case of tools that are made by an outside shop, a purchase requisition, together with the sketch or blueprint and the specifications for the tool, is sent to the purchasing department. This department then issues a purchase order to the tool manufacturer. In the case of company-made tools, a tool production order is issued by the production control department to the company's own tool department. In either case, it is necessary to get a promise of delivery before the date scheduled to start the particular operation that requires the tool. Most delivery promises are undoubtedly made honestly, but unfortunately no promise date is better than the executive ability on which it rests. In most cases these purchase or tool orders must be followed up.

Otherwise, there will be little assurance that the production order for the part will not be held up by failure to receive the special tool on time. In addition to special tools, there are nonstandard tools—tools that may be standard for a particular operation on a standard part, but are not standard commercially. Usually at least two sets of them are kept on hand in the tool crib of the department in which the operation is normally run. While it is not necessary to make them up for a particular order, their condition and availability should be checked before production orders are released to the shop. Standard tools seldom require any particular preparation. This brief discussion of tool preparation is undoubtedly sufficient to make clear the nature and contribution of the preparation function.

Special or unclassified materials needed for special orders present much the same problems as do special tools. In the case of standard materials or parts carried regularly in stores, stock records must be checked to determine their availability for the particular order. The balance of stores records in this type of manufacturing may and usually should be located in the control department under the person responsible for the preparation function.

In most cases, the availability of the right kind and amount of man power is not checked against the requirements of specific orders. The department foreman is expected to maintain the required work force with the assistance of the personnel department. However, the control department may work out, for each department of the plant, a schedule of the daily hours to be run during the coming period; it may also work out a man-power program and schedule when there is normally a pronounced seasonal variation in production and employment. It is certainly as important to coördinate the availability of labor capacity as it is to coördinate machine capacity. This should be done by departments, labor grades, and man-hours. In highly intermittent manufacturing, the availability of machine capacity should be checked for each order. We shall give this problem more attention shortly.

It will be noticed that the functions of control, other than preparation, have to do chiefly with the coördination of primary line activities. Routine planning, in addition, coördinates the work of technical staff planning groups with the needs of the line for information concerning plans. The preparation function is concerned chiefly with coördinating the facilitating services rendered by certain technical staff functions and the requirements of the primary line functions for these services. This is its distinctive and highly important contribution.

Time is a factor in coördinating the provision of tools, materials, and other performance factors. For this reason, preparation must usually follow scheduling. Production control must have sufficient lead time to complete preparation. The foreman of the tool department might very properly refuse to accept an order that is issued today for the delivery of a complicated special tool tomorrow. He might require a personal O.K. by a higher line authority, if the order disrupted his departmental work schedule.

When the preliminary schedule has been modified in accordance with any anticipated difficulties, it may safely be used as a basis for dispatching orders. The problem of available machine capacity will be examined further, before discussing the dispatching function.

Capacity Control

Capacity control is the function of assuring the availability of the proper kind and amount of productive capacity in the place and at the time it is needed. The definition applies to either men or machines. Capacity is a measure of the ability to do work, and is expressed as a time rate of performance. Productive capacity is usually stated in terms of machine-hours or man-hours.

For capacity control, the number of men or machines of each class that each shop department possesses, the number of hours that the department will run during each time period, and the maximum percentage of the theoretical capacity which can safely be scheduled, must be known. This information is usually set up on the records of the load clerk. For example, Fig. 16.8 shows that Shop Department D3M has 20 machines of class L24E, and a theoretical maximum capacity of 960 machine-hours on the basis of a 48-hour week. The fact that the available machine-hours for this group are put at 860 shows that 90 percent is apparently the maximum utilization which can be scheduled. The available capacity of these machines would be 720 hours, or 16.7 percent less, on a standard 40-hour basis. The plant is evidently working overtime. It is paying time and one-half for the additional capacity, in such case.

In intermittent manufacturing, the available capacity should be checked with regard to the requirements of individual orders. This requires a knowledge of the quantity of the item that is to be run on each order, the class of workman or machine required for each operation, the unit process time for each operation, and the date when the particular kind of capacity will be needed. Reports showing the completion of each operation on the order also are needed. The part which is being made under Order 2162

in Fig. 16.8 is usually run in standard lots of 500 pieces.[7] The unit time for operation 2 is 17.3 minutes per piece. Therefore 144 machine-hours of capacity are required for this operation on a standard lot. The order is routed to Department D3M and is run on machines in class L24E. Inasmuch as this operation is scheduled to be completed during the week of February 19, the capacity requirements of the order (144 machine-hours)

MACHINE CAPACITY CONTROL

Number of machines 20 — Dept. D 3 M

1 Shifts Hrs. 48 — Mch. class L 24 E

Total capacity 960 — Avail. mch. hrs. 860

Foreman J. Smith

Order No.	Op. No.	2/12		2/19		2/26		3/5		3/12		3/19		3/26		4/2		
		A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	
2162	2			144														
2172	12			96		96		96										
2175	4							120		52								
2182	7	300		210		100												
2190	13	500		400		200												
2162	2				144													
2190	13				400	400												
		800		850	544	796		216		52								
				544														
		800		306		796		216		52								

Fig. 16.8. A Machine Capacity Control

are entered in the A, or apportioned, column under this date. When the operation is reported completed, the same amount is credited in the R, or released, column. The balance between these two columns at any time will show the load of work ahead for this group of machines in terms of standard machine-hours. According to this figure, there are only 306 machine-hours of work ahead for the week of February 19 because Orders 2162 and 2190 were either completed ahead of schedule or transferred to

[7] The form shown in Fig. 16.8 merely illustrates one method of handling this problem. Others have been used successfully; among them is the Gantt Load Chart. See Wallace Clark, *op. cit.*

other departments and machines. Unless arrangements are made for additional work for these 20 machines, the men running them must be put on short time or transferred to other machines.

The above method was taken from the practice of a small plant. Manual posting might prove to be too slow and too expensive in a large plant. The latter plant would probably use some type of machine posting.

The principal objective of a capacity control method is, of course, information that will enable the practicability of order schedules to be checked. This leads, in turn, to a better utilization of equipment, fewer back orders, and better customer service. In addition, it provides other values that may be quite important. For example, a running record of machine utilization by departments makes possible a better control of requests for additional man power or machine capacity. Such requests are sometimes a defense mechanism against failure to meet production schedules. Any shop executive who has twice as much capacity as he requires should be able to get out his work on time. Similarly, capacity records make possible a better control of foremen's requests for overtime for their men. These records make it possible to get a weekly check of work-in-process turnover. Thus these records may provide an additional check on executive effectiveness.

Some question may arise as to whether capacity control is necessary during a depression when the plant is working at a fraction of its normal capacity. A well-managed plant will continue it even then. As the volume of work decreases, it becomes increasingly necessary to reduce the hours of work, lay men off, and withdraw machines from service, in approximately this order. Whenever productive capacity has to be adjusted closely to manufacturing volume, some control of capacity is desirable. Thus, in the depth of the depression in 1932, many purchasing agents complained that they could not rely on the delivery promises of certain concerns for certain items, and in some cases could not get the deliveries they wanted.

The Function of Dispatching

When the schedule for a production order has been cleared, the shop departments are then in a position to start work on it. Good dispatching is required to assure that work will be started at the proper time and that the order will continue to progress as scheduled. Dispatching is the function of initiating and controlling performance through the proper release of authority to act. With an order control of production, dispatching regulates the progress of work by controlling the authority to commence each

successive operation in each department through which the order is routed. Dispatching transmits to these departments the necessary instructions and information covering their work. This information has to do, of course, with the amount and kind of material to be requisitioned, the cost symbol against which charges are to be made, the proper routing of the order, the class of machine on which each operation is to be run, etc.—in other words, the information previously discussed. It may be conveyed by production papers, such as materials requisitions, route tags, copies of operation tickets or of route sheets representing shop copies of production orders, etc.[8]

The objectives of dispatching are good coördination of primary operative activities, and effective performance, in so far as these values result from the proper release of authority and information to the right department at the right time. What is the right time is a function of the closeness of control that is desired. It would be one thing with a centralized control of shop production in highly continuous manufacturing, and another with decentralized control in highly intermittent manufacturing. In general, the closeness of control depends on how near is the release of authority to act to the time scheduled for action. With decentralized control, dispatching should take place sufficiently far in advance to permit the shop department to line up its work, but not so much so that it will get seriously out of line with other departmental schedules. It is evident also that effective dispatching depends on the prior development of reliable schedules, and that its purposes will be defeated if operations are held up by a lack of some performance factor. In consequence, dispatching should follow scheduling and preparation.

In order to achieve the objectives of dispatching in an order control of production, certain factors are necessary—for example, some means of holding production orders and papers in suspense pending release, so that they will be insured against loss, and furthermore can be located easily and quickly. One simple way is to put them in large manila envelopes in the sequence shown by the operation numbers on the order, and to file these envelopes in standard steel filing cabinets by order numbers. There must also be some means of calling attention automatically and accurately to the necessity for dispatching a particular order.

The closeness of control that is required governs the kind and frequence of operative reports, showing order progress, that will be necessary.

[8] This routine release of information may be regarded as a phase of dispatching, because instructions are often issued in the form of technical orders. Such release may also be regarded as a facilitative service for the function of direction.

Those commonly received from the shop are the operation ticket and the move order. An example of an operation ticket is shown in Fig. 16.9. Such a ticket can be used to indicate the start and finish of an operation in a department.

The move order indicates the movement of material between departments. The shop department also returns its copy of the production order and other production papers pertaining to it. On the basis of these returns, the progress of the order between and through the various shop departments on its routing is checked off on the route sheet, which may be similar to the example shown in Fig. 16.3. When control is decentralized,

PRODUCTIVE LABOR				EMPLOYEE THE JEFFREY MFG. CO. 1713R	CHECK NO.	ORDER NO.
COMP.	INCOMP.	WITH CHECK NO.	CARD NO.			
ORDER NO. 607295					MASTER SHEET NO. 48	

AMOUNT ORDERED	JOB	TOOL NO.	CAT. NO.	PAT. NO.	MK.	DRG. NO.
3	3 SFD 464 Finisher L.H. Mag. Separator comp. Aj. Water Weld. Pipe for mk, 26	607346			2	450F703-65

AMOUNT MADE	TOTAL LIMIT		DAY RATE	LABOR VALUE	
	TIME TAKEN				
PRO RATED AMOUNT	TIME GAINED		BURDEN RATE	BURDEN VALUE	

DEPT. NO.	OP. NO.	MACH. TYPE	LIMIT MINUTES PER PC.	LIMIT MINUTES SET UP		OPERATION DESCRIPTION
E5	1	SH12	1.2	8		Saw

Fig. 16.9. An Operation or Job Ticket. (Courtesy, The Jeffrey Mfg. Co.)

orders are usually dispatched to departments rather than to operations. When the movement of the order from one department to the next on its routing is thus checked off, the papers for the next department beyond that are withdrawn from the dispatch file and forwarded through the factory mailing system or whatever system is used for the transmission of written communications. For example, when the shop returns show that Order 1280-121-1 in Fig. 16.7 has been completed in Department 15, the production papers required by Department 25 for operation 9 should be dispatched. With an operation sheet system, it would be too late to dispatch the papers for operation 8 to Department 11. In this way, dispatching assures that the order and its successive phases start on time and do not get too far ahead of schedule. The functions of comparison and corrective action must prevent it from dropping too far behind. It has been pointed out previously why the one may be quite as undesirable as the other.

The above procedure conforms to the requirements of good dispatching, and, in intermittent manufacturing, may make possible a sufficiently close control of progress. However, it has its weaknesses. Considerable time may elapse between the dispatching and starting of an operation, and the amount of time may vary considerably between departments. Thus, according to Fig. 16.7, production papers are released to Department 11 about 4 workdays before operation 8 is due to start, and to Department 25 about 1 day before the start of operation 9. A loose control may result in a higher amount and a lower rate of turnover of our work in process inventory. A longer lead time may be required to meet customer shipping dates. It is possible to overcome these difficulties without resorting to detailed, centralized dispatching, however.

The Order-of-Work Method

This method of dispatching permits a closer control of production. There is necessarily a lesser degree of decentralization. The current trend, in manufacturing concerns, is in the direction of the maximum practicable decentralization of managerial functions. This is particularly true for operative controls in concerns that are engaged in intermittent manufacturing. The reasons will be found in the principles of decentralization that have been stated previously. The order-of-work method, accordingly, is not in consonance with current manufacturing policy. It may have value, nevertheless, in plants where conditions require temporarily a close control through dispatching.

The order-of-work method makes it possible to release the authority to run an operation shortly before it is scheduled to start, without making it difficult or impossible for the department to complete its preparations. This method is based on the principle that the closeness of control may be greatly increased, by separating the dispatching of technical orders and information from the dispatching of operational orders. These orders must still be coördinated properly. The instruments shown in Figs. 16.10 and 16.11 illustrate one way of applying these principles.

When this method is used, the production papers for a given order, including a duplicated copy of the operation list shown in Fig. 16.10, may be sent to the various departments concerned as soon as they are made out. These papers carry no authority to act. A copy of the operation list is in a tickler file against the scheduled starting date for the first operation. On any given day, the operation lists for all orders on which operations are scheduled to start the next day are automatically brought to the attention of the dispatch clerk. These lists are sorted by departments. The

operations are listed on the order-of-work sheet for each department, as in Fig. 16.11. It is made out in duplicate. The operation lists are then returned to the tickler file against the scheduled date for the next operation. Both copies of the order of work for each department are forwarded to it in the afternoon. A department cannot start orders that do not appear on its order of work. The following morning, the foreman goes over the orders listed, checks the operations that can be started, and notes on the

No. of pieces	Date	Order No.
Name		
Material		

	Operation	Dept.	Mach.	Begin	Begin	Finish

MANUFACTURING ORDER

Fig. 16.10. An Operation List. (Courtesy, Remington Rand, Inc.)

original copy, in the columns headed "Reasons Not Started," why the others cannot be. The original copy is then returned by the foreman to the control department. He sends in the duplicate copy at the end of the day. Some operations which were reported in the morning as started may have been held up during the day. Others which were reported held up may have been started. Those which have not been begun are entered by the dispatch clerk at the top of the department's order of work for the next day. These orders continue to appear daily until the order is out of the department. The dispatch clerk checks on the route sheet those operations

that have started. A daily report of holdups is prepared for the line executive who is immediately responsible for their prompt removal. This may be a superintendent, a general foreman, or both. The foreman should remove promptly those interferences that he can handle quickly himself. The control department can speed up or retard the progress of specific orders by this method. The departmental management has less flexibility in handling its load of work, on the other hand. Its accountability for results is reduced accordingly.

Dispatching is a linking function between the exercise of control at a given managerial level and execution at a lower level. This is true whether control is highly centralized in the hands of a line executive who exercises

WORK TO BE STARTED IN....03 M........DEPT. ON.....2/13

Part and Order No	Oper. No.	Oper. Name	Mach. No. or Class		Reasons not Started	Will Start
P21 - 1260	8	Mill Base	M2P			
H28 - 1132	3	Mill Adj. Block	M3H		No Tools	2/14 A.M.

Fig. 16.11. An Order of Work. (Courtesy, Remington Rand, Inc.)

it personally, as is sometimes the case in small concerns, or whether it is exercised through a general staff agency. This is a distinctive characteristic of the dispatching function. In the factory, orders and instructions are sent principally to the superintendents and foremen. In production control, therefore, dispatching links chiefly the levels of major and minor operative management.

Direction and Supervision

Direction has been defined above as the function of instruction concerning the nature and requirements for the proper execution of a plan. The production control department constantly sends out routine instructions to the various operating departments. This is obviously a routine phase of direction. In connection with the order-of-work procedure, it was stated

that routine direction can be differentiated distinctly from dispatching. However, any significant departure from the conventional or standard situation must be referred at once to the responsible line executive for a decision. This executive may give his decision directly to the subordinate line executive in charge, but he should inform the control department promptly, so that its records may be adjusted properly. If time permits, the department may transmit the executive's directions and coördinate their execution. Nonroutine direction is the more important phase of this function. A plant, for example, may receive an order that calls for a modification of one of its standard products. The plant manager may confer with his line and staff subordinates concerning the best way of handling the problem. He arrives at a decision, gives the necessary instructions, and issues orders for the initiation of action. The instructions and orders may be given orally. Important oral directives should be confirmed in writing. Direction, in this example, takes place after the dispatching of the order from the company's general offices. Such direction results in the issuance of orders to plant divisions or departments on lower levels of the organization. Direction may also take place in connection with the control function of corrective action. Some serious interference, for example, may hold up the execution of the order after it gets into production. The plant manager, or a line superintendent, may confer again with those line and staff subordinates who are immediately concerned with the difficulty. The responsible line executive arrives at a decision, gives the necessary instructions, and issues orders for the initiation of action. Direction takes place, in this case, after the dispatching of the production order by production control to certain primary departments. The nonroutine phases of direction, in any case, involves face-to-face leadership of subordinates by their immediate superior. This is a line situation. The purpose of direction is to set up certain supplemental constraints and regulations that will assure a proper execution of the order. Direction must be regarded, accordingly, as a line phase of control. Direction may result in a further release of authority, or a modification of an original release. A breakdown of staff production control may result, therefore, unless the responsible line executive coördinates the exercise of his right of command with the control department.

Supervision is the function of assuring that work is being done in accordance with plans and instructions. This function involves overseeing and checking work while it is being done, to make certain that instructions are understood, the individual has the requisite ability and training, etc. Supervision is the only control function that can result directly and im-

mediately in corrective action for execution that is currently in progress. The production control department can give a limited amount of aid by means of the reports that it receives constantly. In general, however, supervision is exercised continuously through conferences and other contacts between superior and subordinate at every organization level. It is, accordingly, another line phase of control.

Training is largely a specialized application of direction and supervision. The training of line operatives is regarded generally as a major responsibility of the line organization. The line operative executive is not relieved of this responsibility by whatever service he receives from the education and training section of the personnel department. This placement of training responsibility on line executives, at every level, tends to confirm the above concepts of direction and supervision.

The Comparison Function

Comparison has been defined as the function of determining the degree of agreement between actual and predetermined performance. The production control division of a manufacturing concern must produce customer values, with due regard for requirements of quantity, quality, time, and costs. Such primary values result from the application of men and machines to materials in the creation of certain product utilities. The production control department is responsible chiefly for the comparison of values relating to time and quantity. The comparison of the quality of work with quality standards is mainly the responsibility of the inspection department. This department must inform the production control department of the amount of work that is scrapped on an order so that the latter can correct its records. The comparisons of actual and predetermined costs and expenses are chiefly the responsibility of the cost and budget departments, respectively. As a coördinative staff agency, however, production control may receive the reports of various technical staff departments, such as those just mentioned. Production control may combine them with its own reports to give a composite picture of operations to the line executives of the production division.

It follows that the immediate objective of comparison in production control is to provide information that will show the status of orders relative to predetermined standards of progress. Comparison must tell what action is taking place, where it is being carried on, what results are being achieved in so far as they relate to quantity and time, and how they compare with what was expected. Provision must be made for the four fundamental phases of the comparison function noted earlier: collecting prog-

ress information, recording, comparing, and reporting to a subordinate, coördinate, or higher line authority.[9]

In intermittent manufacturing, the production control division will receive a variety of returns that show accurately the kind, quantity, and quality of the work, the time when it was completed, the workplace or department where it was done, and the name of the operative or foreman responsible. Most plants of this type do not permit work to move from one department to another except on the authority of a move order signed by the foreman or the inspector of the sending department. This order carries such information as the production order number, the part number, the quantity moved, and the symbols of the sending and receiving departments. Production control may also receive copies of job tickets, similar to the one in Fig. 16.9, if it is necessary to check the start and finish of operations. Production control may receive interruption reports that will inform it of any interference with production. When the last operation is completed in a department, the control department usually gets back the blueprint of the route sheet, or whatever served as the shop copy of the production order. The receipt of this copy, signed by the foreman as completed, usually closes out the work of the particular department. An examination of these forms and the information they convey will show that they meet the requirements of satisfactory returns.

There should be provision for the proper initiation and completion of action for each major phase of a project, as well as for the project as a whole. For example, to facilitate closing its own records, the cost department usually requires some notice that a production or manufacturing order has been closed out in the shop.

Some hundreds of orders for many different parts may be in production or about to be released. The number of operations required to complete a part may range from a few to 200 or 300, and may be run in many departments. Each finished product may be an assembly of many different parts or subassemblies. In consequence, a great mass of production information is likely to pour into the control department in a more or less continuous stream; this must be handled quickly and recorded in some form that will facilitate comparison with progress standards or other criteria of proper performance. One simple device for this purpose is a

[9] "Feedback" has become a familiar term. It refers to the communication of information concerning the status of performance to an individual or instrument that must take corrective action. It has to do, therefore, with cybernetics. It is identified with reporting, which is phase 4 of our analysis of the comparison function. All 4 phases of comparison are performed automatically, by electronic mechanisms, when we have complete automation.

copy of the operation layout, or route sheet. A schedule shows the rate at which an order in production should move through the operations and departments that process it. It is therefore the standard of progress for the order. A route sheet may have schedule columns, as shown in Fig. 16.3. It provides a direct comparison between actual and predetermined progress as the completion of operations and the movement of the order to and from departments are checked off.

It is a simple matter to note the nature, degree, and significance of any deviation of actual from predetermined progress, particularly if the route sheet carries notations on any holdups that have developed. If the order seems to be dropping behind its schedule, the progress clerk can easily flag the route sheet in some way when he makes the entry. However, the progress clerk should check these records periodically—each night, perhaps—to determine what orders should be brought to the personal attention of the plant manager and the responsible superintendent. To guide him in this, there must be a definite policy. Thus the production manager may decide that any order which is a certain number of days behind schedule, say three, is to be regarded as a back order and brought to his attention. It is assumed that any orders that are behind less than this time can be brought back on schedule by subordinate line executives and the control department without the assistance of higher line executives in the plant. The back order report may be made by the progress clerk. This report will show for each one the production order number, the part number, the operation and department numbers, the number of days behind schedule, any reported causes of the holdup, any action that has been taken to relieve it, etc. It is evident that the preparation of this report involves an application of the exception principle. It would be a waste of his time certainly, to give the line executive a progress report in which back orders and those on time were listed indiscriminately.

The route sheet is only one of many comparison instruments for progress control in intermittent manufacturing, even though it is simple and effective in many circumstances. Graphic devices in the form of progress charts or control boards are frequently used. The general nature of a progress chart may be illustrated by Fig. 16.7. It is assumed that the chart was drawn originally on tracing cloth or paper, except that no dates were entered and the department and operation numbers were entered for the other parts also. A blueprint of the chart was made for Manufacturing Order 1280, and the dates shown were then entered on the calendar scale. As returns were received from the shop for Production Order 1280-121-1, showing the completion of the successive operations in the

various departments, they were crossed off on the chart with red pencil. The extension of the red line from left to right would show the progress of the order relative to its schedule. The movement of the other orders for the parts necessary to assemble product 121 could be shown similarly.

Clerical Expense and the Comparison Function

A detailed central control of production may be undesirable, and an unnecessary expense. It is not in consonance with the tendency to decentralize control under conditions of intermittent manufacturing.

This expense can be reduced frequently by applying the exception principle to the problem of operative reports. The policy, for example, may be as follows. Production information should be reported to the plant control department only for orders that are behind schedule. The frequency of reporting should be that minimum which will permit effective corrective action to prevent delivery failures. The control department is responsible only for the interdepartmental coördination of production. The control of production within a shop department is the responsibility of its manager, the foreman. It will be assumed that the frequency of reporting in this company is weekly. A week number is assigned, in such case, for each week in the year. The number of the week in which a department is to finish its work on an order is stamped on the production suborder for the department. An audit of each department's production order file, or dispatch rack, is made at the beginning of each week by a clerk from the production control department. He makes a record only of those orders with previous week numbers that are still in the department. It is assumed that all orders for previous weeks that are not picked up in this manner have been shipped from the department. The status of each back order is entered on its progress record in the production control department. A back-order report is prepared for the responsible line executive for such corrective action as may be necessary.

Some method of this kind is frequently applicable with a job-order control of the production of light parts. It is evident that it reduces the expense of reporting and recording production information to a minimum. It is not applicable with heavy manufacturing of capital equipment, such as large turbo-generators. The production time for each operation may be too long to make it practicable.

The Turnover of Work in Process

Increased attention has been given in many plants, during recent years, to the maintenance of a high rate of turnover of work in process. This in-

ventory may represent a substantial proportion of our working capital. This greater attention may be due to increasing mechanization, higher break-even points, smaller profit margins on sales, and/or a recognition of the relation of inventory turnover to the rate of profit on capital.

The accomplishment of higher work-in-process turnover requires the placement of responsibility on the department manager, or foreman, for the optimum rate of movement of work through and out of his department. This is the maximum rate that is consistent with the required quality of production. This placement of responsibility may not be effective unless there are departmental turnover standards that will permit the establishment of the manager's accountability for results. Reports showing weekly turnover rates by departments can be made by production control. It should have the necessary information in its capacity control records. The machine-hour or man-hour load of work that has been scheduled for a department during a given week should be known. A copy of the move order shows when a production order is received or shipped by a department. The load of work that is actually ahead of each class of machine in the department is known, therefore. The machine-hours of work shipped from the department during the week, divided by the average departmental work load for this period, provide a measure of the weekly rate of turnover of work in process. A standard of good performance can be established for the department from its record over a period of time. Such turnover ratios supplement the inventory turnover ratios, that may be computed, in monetary units, by the comptroller's office.

Corrective Action

Corrective action is the function of controlling the tendency of actual performance to deviate from planned performance. Its objective is a prompt removal of interferences with a satisfactory achievement of the final objectives of the project. In production, prompt delivery of an order when scheduled is usually one of these objectives; it is a requisite for such fundamental values as good turnover, a satisfactory inventory position, good customer service, low unit costs, etc.

A superintendent may receive a report from production control that an order has been held up in a given department because of a machine breakdown. Production control may have called the maintenance department office to find out how serious the break is, how long it will be before work can be resumed, etc. It may recommend that we reroute the order to another department that has a similar machine, hold it up until the machine has been repaired, work overtime until the order is back on

schedule, or take some other action. The final decision should be the personal responsibility of the lowest-ranking line executive who has the authority to make it. This decision should be coördinated with production control, and handled through it if possible. The control manager's position of staff leadership in the coördination of action may be weakened otherwise. We must get action quickly, following the decision, because the situation is an emergency to some extent. The necessary orders and instructions may be issued by telephone and confirmed later with written orders. Inasmuch as the situation is unusual and perhaps serious, the superintendent may check up personally on the execution of his orders or call for special reports on them. If the machine is approaching its retirement age and has caused holdups several times previously, he may have to consider whether to replace it with a new machine, to rebuild it, or to retain it for use on roughing operations only. This will mean more decisions and more orders and instructions.

It was noted in Chapter 5 that corrective action can be broken down into its operative phases and its administrative phases. It is apparent that the line executive is going through these phases. They concern specifically, in this instance, an interference with the execution of a production project, an order for a specified quantity of parts of a given kind.

Shop Departmental Management

Some performance of each organic function of management is required at each level of the organization. The emphasis that is placed on each function varies with the level and the extent of managerial decentralization. Top management is general administrative management. The emphasis at top organizational levels tends to be on general administrative planning for group accomplishment of long-range objectives. Middle management includes minor administrative and major operative management. Bottom management is minor operative or supervisory management. The emphasis at the bottom levels is on the operative control of project execution by individuals or teams. It is concerned chiefly with the accomplishment of the immediate objectives of the department and the organization.

We have noted the trend toward the maximum practicable decentralization of managerial functions, responsibilities, and authorities. The degree of decentralization that is practicable is much greater with intermittent than with continuous manufacturing. The reason for such decentralization is obvious: execution takes place at the bottom of the organization. It is accordingly desirable to place responsibility for results on the lowest-ranking individual who can discharge it. His accountability for results

must be established. The foreman or manager of a shop department, for example, is in a better position, with increasing managerial decentralization, to provide leadership for the department's operatives. He becomes increasingly accountable for the accomplishment of the department's production objectives. This accountability should include all phases of accomplishment, whether they have to do with quantity, quality, time, or expense of production.

Such decentralization may make it desirable to have fewer separate departments of larger size that are headed by department managers of greater ability. It is economical to pay higher salaries to such men. This organizational trend has been illustrated in Fig. 15.5. The department, in this case, has three managerial levels. These levels are represented by the first line supervisors, the assistant foremen, and the foreman or department manager.

The departmental organization has many responsibilities. The manager of a department of this size must participate in operative planning and organizing for the work of his organization. His greatest responsibility, nevertheless, is for the control of the quantity, quality, time, and expense of production. Under a decentralized order control of production, the central control office plans, schedules, and dispatches to the department, rather than to the machine or the workman. The shop clerk, in Fig. 15.5, controls production, under the direction of the foreman, subject to the schedule dates on the shop copy of the production order. This clerk issues operation tickets to the men, move orders, and other control instruments. He accordingly performs a coördinative staff function in the department. In the case of a starting operation, the foreman must see that the right quantity and kind of material is run on an order. He must account for its use and disposition. The foreman must see that the cost of each operation on each order is held within the limits of standard costs. He must also see that the order is shipped from the department on or before the scheduled time. The departmental executives must train their men, execute the leadership functions necessary to maintain morale, keep the controllable items of indirect expense in shop operations within budget limits, and carry on other functions of shop departmental management.

Departmental Production Control

All the basic control functions are performed by the foreman and his subordinates, when departmental management is decentralized. The production control department performs the staff phases of control for the department, when departmental control is centralized. The departmental

executives perform chiefly the line functions of production control, in such case. Our discussion has assumed that departmental management is decentralized in the maximum degree that is practicable. It is necessary, in consequence, to indicate briefly the nature of the performance of the 8 control functions within the department.

In intermittent manufacturing, the ability to execute an operation in accordance with its schedule depends on man or machine capacity and its availability relative to the time when it is needed. Men and machines are basic production factors. Any device for controlling production in a primary operative department should be based accordingly on capacity-operation-time relationships in performance. A great many shop production control devices have been developed. The device, whatever it may be, should show at least: (1) the load of work ahead of each machine or workplace, (2) the specific jobs to be done at each machine or workplace, (3) the order in which they are to be put through, (4) the job in process on the machine, and (5) the status of preparation for the next job in line for the machine.

One of the earliest devices is the Taylor planning board, illustrated in Fig. 16.12. On the hook-type board there are 3 sets of hooks for each

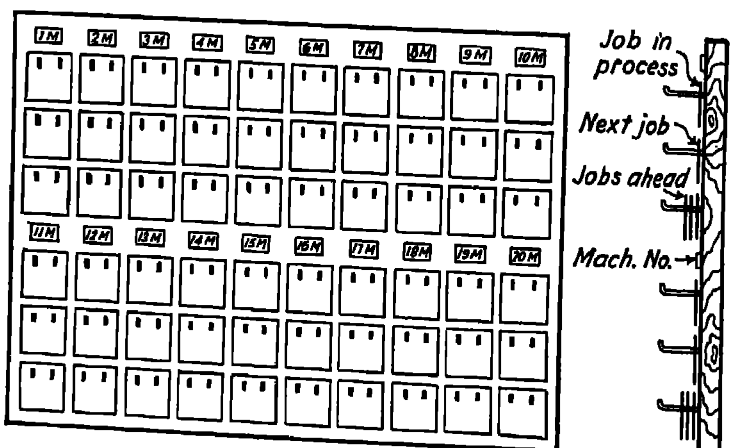


Fig. 16.12. The Hook-Type Planning Board

machine or workplace. The top set holds the operation ticket for the job at present on the machine, the middle set holds the operation tickets for the next job to be done, and the bottom set holds the operation tickets for jobs ahead for the machine in the order of their schedule dates. It is

simple and practicable in many situations of the type we are discussing.[10] It will serve to illustrate the point that all the organic control functions must be performed by the shop organization when production control is decentralized. They must be performed within the limits of interdepartmental schedules that are established by the central control office.

The problem can be illustrated by a production order for a specified quantity of certain parts. One of the operations must be performed in a department that is designated on the operation layout or route sheet for the order. Action on the operation is authorized by the release of whatever production papers perform the functions of a production suborder. It will be assumed that a blueprint copy of the route sheet serves as a departmental copy of the production order. This blueprint copy will probably be sent by the central control office, along with any other production papers, through the factory mail system. This copy may be received early in the morning and afternoon work periods. When it comes in, the foreman usually goes over the copy with his shop clerk. He indicates whatever special action should be taken on it. What is to be done is shown broadly, as to kind and quantity, by the order. In standard operations, the decision on how the operation is to be run may have been made previously by the time-study department. It may be recorded on a standard instruction card. When the time comes to run the operation the foreman may wish to give specific directions to the workman regarding certain details of setting up the machine for the job, nevertheless. In a nonstandard operation, the foreman may have to determine in some detail the best method of doing it. Otherwise the decision will be left largely to the employee. This is usually undesirable. While the blueprint of the route sheet tells what class of machine should be used, it makes no attempt to specify the particular machine, unless control is more highly centralized than we have assumed. Some of the older machines may be quite capable of doing roughing operations. These machines may be unable to meet the more rigid standards of high-quality work, however. On the basis of such factors as the class of machine to be used, the condition of the various machines in this class, the quality requirements of the operation, and the load of work ahead of each machine, the foreman must determine the particular machine to which the job should be assigned. He may have to make the same decision regarding his operative employees. Some may be competent to operate this type of machine, but they may not be equally

[10] Another well-known device employing this capacity-operation-time relationship is the Gantt Layout Chart. See Wallace Clark, *op cit.*

skillful and experienced in its operation. Their rates of pay may differ accordingly. No foreman can afford to use skilled men on unskilled work, and vice versa. The foreman may decide, for these reasons, to shift a workman from one machine to another for the operation in question. For the most part, these decisions are routine, inasmuch as they parallel many previous decisions on similar jobs; nevertheless, they involve the determination of what should be done, how and where it should be done, and who should be responsbile. Consequently this may be regarded as the routine planning phase in shop production control. These decisions are noted on the blueprint of the route sheet by the shop clerk. The foreman is relieved from routine duties in connection with their execution. He may devote his time to removing interferences with production, handling employee complaints. training his men, and other duties of a nonroutine nature.

The estimated or standard time necessary to run the required quantity on a given operation is often shown on the production papers for the order. The departmental completion date for the order or operation should also be shown. Since the bottom set of hooks on the hook-type planning board shows the jobs ahead of each machine, it is merely a matter of mental addition to determine the hours of work ahead of the machine up to any given job posted against it. The foreman can readily tell which machines will be open to handle the operation in time to meet its schedule. He can arrange accordingly the starting order of the operation tickets posted against the particular machine. An example of such a ticket was shown in Fig. 16.9. A departmental scheduling function in shop production control has been performed. When the planning board is used, two copies are frequently prepared for each operation and hung in the proper order on the bottom set of hooks for the designated machine.

The preparation function in departmental control has to do chiefly with checking the availability of the various production factors within the department. For example, the movement of work between departments is controlled usually by means of a move order or transfer ticket. This order may be originated in triplicate by a clerk in the sending department. The move ticket identifies the order, the part, and the last operation completed on it. It states the sending and receiving departments. This order shows the quantity of good work that is being moved. The move ticket does not authorize the movement of the work out of the sending department until an inspector has checked the work and signed the ticket. This is done to make certain that no substandard work leaves the department. A large department will probably have an assistant foreman in charge of certain

services concerning the provision of tools and materials. One of his duties may be to check incoming orders. After he has signed for them, one copy of the move order may be returned to the sending department, and the remaining two turned in to the shop office. The shop clerk may immediately forward one of them to the central control office, and use the other to post the availability of the job. Reference to the shop copy of the route sheet, which has probably been filed by production order number, should show the machine to which the job has been assigned; it can then be located on the planning board easily. The job ticket for the operation can be checked distinctively with a colored pencil. If the job tickets for an operation move up to the second set of hooks without this distinctive mark, this is a warning to check the status of the job in the department or with the central control office. As soon as the next job for a machine becomes available, a departmental transfer order, moving the work up to the machine, can be issued. The work of moving the material is done by department truckers under the assistant foreman. When more than one operation on an order is done in one department, a similar problem exists. Of course no job ticket should be issued to a workman unless it shows that the work is available. The time of the man and the machine would be wasted if we did. It will be noted that the assistant foreman and his men render a specialized staff service of facilitation having to do with the handling and movement of materials and tools. In assuring the availability of work before releasing operative authority, the shop clerk performs a phase of the preparation function in departmental control. Similarly, the availability of tools should be checked before a job is released. Some concerns maintain standard tool lists for operations on standard parts, copies of which are filed in the department's tool crib. When a job ticket calling for work on a standard part moves into the second or make-ready position on the board, the shop clerk has merely to advise the assistant foreman of the order, part, and operation numbers for the job; the latter may wish to check personally the availability of any nonstandard tools that are required. The tool crib clerk withdraws the tools specified on the standard tool list, and places them in a tote box. These tools may be issued to the workman when he calls for them, or be delivered direct to the machine before the job is begun. In every case, the workman must deposit in the tool crib a brass check bearing his number, sign a tool requisition, or give some other evidence of possession of the tool. The department is charged for the tools. It must charge them against the workman when they are issued. He is released from this responsibility when he returns the tools in usable condition. In the case of

nonstandard parts, the tooling for each operation was probably worked out by the manufacturing engineer's department when the job was processed. And it will appear on the shop copy of the route sheet in such case.

Dispatching in shop production control is the function of releasing to the workman operative authority to do an operation on an order. It is an important factor in coördination because it enables the shop to make certain that the workman runs the right jobs in the correct order at the proper time. Dispatching may be done by release of a job ticket to the workman, this ticket usually being in duplicate when a planning board is used. When the workman has finished a job, he brings his job ticket to the shop office window. The ticket usually shows the machine number. The duplicate copy is on the top set of hooks for the machine. This copy can be found easily on the planning board. The pair of tickets on the second set of hooks is then removed; one is given to the man, and the other is hung on the top set, showing that the job is in process on that particular machine. It may be necessary, with some types of incentive plans, to time-stamp simultaneously the tickets for the completed job and the new job.

After the completion of the operation has been checked on the route sheet or production order, one of the duplicate job tickets for the completed job is forwarded to the central control office, and then to the cost department. The other may be held pending receipt of an inspector's report showing the quantity and quality of the work. It is then forwarded to the payroll department. A departmental move order is made out, authorizing the movement of the work to the inspector or the next operation.

The remaining control functions—direction, supervision, comparison, and corrective action—also must be carried on by the foreman and his assistants. It may be sufficient to point out, in the case of direction, that much of the foreman's time is spent in giving advice and assistance to his men concerning methods of doing the work. In supervising, the foreman may check from time to time the quality of the work produced. When operations are difficult or a new man has come on the job, the foreman may observe the worker's methods carefully to make sure that he understands the work and can do it efficiently.

The planning board should show the status of jobs relative to their completion dates. It is the foreman's responsibility to inspect the board frequently, and to push those jobs that appear to be falling behind their schedules. When a machine breaks down or a job is held up for any other reason, the machine should be flagged on the board with some device, such as a colored price tag, which will call attention to it. The foreman

and his assistants are responsible for the prompt removal of holdups, in so far as this is within their power. It is evident that these are functions of comparison and corrective action. When the last operation in the department is completed, the route sheet, or whatever serves as a shop departmental production order, is withdrawn from the files and sent to the control office. This is the final close-out of the order. The department files and records should be cleared of all production papers relating to it. The control office should receive complete information concerning it.

Thus we see that with a decentralized job order control of production, the departmental executives are required to perform all the organic control functions in the area over which they have jurisdiction. The procedures for carrying out these functions vary with differences in environment between concerns, but the functions themselves do not change fundamentally. The procedures described above are of value chiefly as they illustrate the general objectives, principles, factors, and methods entering into the performance of these control functions; they would operate satisfactorily only under the conditions described. Furthermore, there are other methods that may be used.

The Control of Idle Time

An underlying condition of economy in manufacturing is ability to get continuously the maximum practicable production from each machine and each square foot of factory floor space, in so far as the volume of production will permit. Interferences with production, certain of them recurrent, make it difficult to meet this condition, as well as to control production effectively. Hence it is desirable to have adequate and accurate information concerning them in order to study their elimination. The following method will illustrate the problem.

When there is a holdup, the employee clocks out on his job ticket. The shop clerk makes an entry showing the cause of the delay, and notifies the foreman immediately. When the interference has been removed, the workman clocks back on the job. He is paid for this idle time, the duration of the holdup, at his hourly base rate. An employee should not be penalized for idle time for which he is not responsible. If there should be an appreciable difference between the hourly and the incentive base rates, it is to the employee's advantage to report the interference promptly.

There are several ways of attacking the problem of idle time. H. L. Gantt developed valuable graphic methods.[11] There are also electric devices that record stoppages of operations and their causes, when at-

[11] See Wallace Clark, *op. cit.*

tached to a machine. Whatever the method, it should provide accurate information concerning the causes of interferences. These causes should be classified for each department by kind, frequency, duration, and cost. The costing of interferences is done by the cost department, of course. The idle-time report for the plant may be made by the production control department, however. It is primarily a report for the administrative control of departmental operations. It can be made quickly and inexpensively, in any case, when the information is recorded on tabulating cards. A copy of the report goes to the department foreman, as well as to his line superiors. The cost of idle time should appear on the departmental expense report. It should stimulate the initiation of expense-reduction projects by higher line executives, as well as by the foreman.

The Inspection Function

The standards of quality are equally as important as the standards of quantity, time and expense. Quality control methods should provide: (1) an effective method of comparing the actual quality produced with the standard, (2) a method of recording quality results and their trends, and (3) a method of noting the quality of work on the original record of the employee's production and earnings. This is necessary in those plants that relate incentive earnings to quality as well as quantity. Serious losses may result from a failure to maintain quality standards. The foreman and his line subordinates produce quality. They are responsible for it, obviously. Our plant inspection department, under the chief inspector, is responsible for determining the degree of quality that has been produced. It is responsible, furthermore, for maintaining quality standards. This is a staff responsibility.

There are many ways in which these fundamentals can be applied. The following are typical: when the employee completes an operation on an order, he checks and initials the operation on the route tag, sets the work to one side, takes his operation ticket to the shop office. He receives the operation ticket for his next job. The work is moved to the inspector, who notes on the route tag the quantity of good work. He makes out an inspection report showing the order, part, operation, and employee number, the quantity of work passed, the amount rejected, and the cause thereof. One copy is turned in to the department office for use in adjusting the quantity of good work on the employee's job ticket; another copy is usually sent to the chief inspector's office. Finally, the inspector makes out a move order showing the quantity of work moved and other identifying information; this authorizes the movement of the good work to the

next operation or department. The chief inspector's office should have also an administrative control of quality, as well as an operative control. This control should enable us to compare the kinds, frequencies, costs, and trends of quality deviations by departments.

Departmental Cost and Expense Control

The department foreman, or manager, becomes accountable for expense control increasingly, as line managerial responsibilities are decentralized. He may receive reports from the cost department, comparing actual with standard costs by orders and operations. This manager may receive reports from the budget directors office, comparing actual and budgeted expenses. These are staff services that are rendered usually by the comptroller's division. The foreman is responsible, nevertheless, for holding his controllable expenses to standard, or better. This problem will be discussed further when the functions of accounting and finance are considered.

PROBLEMS

1. A truck body corporation manufactured bodies for motor trucks. Although all the bodies went through essentially the same processes, identical bodies were seldom ordered. The orders received by the sales department were sent to the control office after their O.K. for credit. After consulting the routings of previous orders, the control supervisor routed to the various shop departments the different parts and assemblies required. Route tags, operation tickets, instruction cards, move orders, and tool and equipment lists for each part and subassembly were made out by clerks in the control office, and forwarded at once to the shop departments. Each department foreman was advised of the shipping date promised for the order. A shop clerk, who reported directly to the foreman, assigned the jobs to the various machines, and was responsible for the movement of work from one machine to another. He sent a report of each day's production to the control supervisor, who checked it against the scheduled shipping date. Whenever the supervisor believed that there was danger that the order would not be shipped when promised, he sent out a special trouble shooter to hurry the job along. The control supervisor was concerned, however, about the necessity for using trouble shooters to expedite the progress of orders. He believed this to be a sign of inadequate production control.
   (a) Which of the fundamental phases of control were improperly or inadequately developed?
   (b) What changes in this procedure would you suggest? Why?
2. A concern manufactures a simple product that is an assembly of 7 parts. This product is not carried regularly in stock, but is made to the customer's order. The plant works 5 days a week, exclusive of Saturday and Sunday. The total setup, process, and float time for each of the 7 parts is as follows:

Part 1	6	manufacturing days
2	10	
3	15	
4	9	
5	16	
6	19	
7	8	

Parts 1, 2, and 3 are a subassembly; 2 days are needed to complete it. The final assembly time is 4 days. The manufacturing times are based on a standard quantity of 100 completed units of product.

(a) Draw a manufacturing assembly diagram for the product. If an order for 100 units were received for shipment on Tuesday, June 10, on what day should Part 6 start production? If the order called for 75 units, what would be the starting date for this piece? Is it sufficiently accurate to make a proportionate reduction of the time scale?

(b) If an order for 100 units was received on May 16 for delivery on June 10, and the plant decided to accept it in view of the good margin of profit on the item and the customer's importance and long-standing patronage, what parts would require special handling and follow-up by the production control department? What alternative courses of action would be open to the control department in handling this order?

3. The industrial engineering department had a staff responsibility for the design of manufacturing methods in a concern engaged in intermittent manufacturing. Information concerning the equipment to be used and the sequence of operations was supplied by that department. Route sheets were written on the basis of records of previous jobs involving similar operations. Time standards were specified by checking records on file which included similar operations. Such preparation often took considerable time and resulted in information which frequently had to be modified for use in production control. This engineering department was headed by a man with great practical experience but little formal training in industrial engineering. He had been a skilled tool and die maker in his younger days, however.

(a) What function of production control is involved? What should be the relations between production control and industrial engineering?

(b) Why was the information from industrial engineering unreliable? What could production control do about it?

4. The following record of machine loading was taken as of the end of a certain week for the lathe section of a shop department. The figures represent machine-hours of work.

Order No. Prev. Wk.	Lathe	Loaded	Shipped	Balance	Mach.-Hr Load
		—	—	—	50
57		135	35	100	150
58		44	20	24	174
60		36	—	36	210

(a) Compute the work-in-process turnover for this section for the week. What is the equivalent annual turnover, assuming that the plant works 50 weeks out of the year?

(b) Is this figure good or bad? What additional facts do you need to know?

(c) What contribution, if any, can such a turnover figure make to manufacturing economy. The comptrollers division probably computes turnover figures also. Are we duplicating the work of our accountants?

CHAPTER 17 •

• Production Control with Continuous Manufacturing

The General Conditions of the Problem

THERE is a complete range of continuity in manufacturing from highly intermittent, through semi-intermittent, semicontinuous, to highly continuous manufacturing. There is an infinite number of degrees of continuity between the extremes. It is not necessary, however, to recognize the fine gradations. All the changing conditions of industry and manufacturing, and their effects on the application of control principles, cannot be examined in a general text such as this. The following discussion will be confined to the highly continuous manufacture of an assembled product. We shall gain thereby a contrast with the problem of control in a highly intermittent or discontinuous industry. This was discussed in the previous chapter. The principal characteristics of continuous manufacturing will be brought out. The extent to which its economies are natural advantages in large-scale manufacturing will be considered. It will be shown that the organic control functions must be performed even in this radically different industrial environment.

Most of the economies of continuous manufacturing have been noted previously. These economies include such advantages as a short production cycle which makes for a high turnover, minimum inventories relative to the volume of production, and quick deliveries to the customers. A minimum investment in plant and equipment should result from a better balance of production. There may be a stimulus to greater production per employee as a result of a smooth, continuous flow of work. Other economies may result from the simplicity, accuracy, and low cost of production control. Wage and incentive payment methods are usually simpler than with intermittent manufacturing. Other advantages will become apparent during the following discussion of production control. There are, of course, still others connected with purchasing, merchandising, and finan-

cing that are important. These advantages do not enter directly into production control, however.

Continuous manufacturing was defined earlier as that type in which labor and equipment are applied continuously to materials for an extended period of time. In the highly continuous manufacture of annual models, this period obviously is the manufacturing year. This type of manufacturing requires a volume of production sufficient to make possible the economical balance of machine capacity and man power for the successive operations in the manufacture of a part or assembly. This does not mean necessarily that only extremely large plants can engage in continuous manufacturing. Many large corporations have been decentralizing operations on a product-line, profit-center basis. These companies have been establishing plants in widely separated communities. They have not abandoned mass production, however. Any abandonment of continuous manufacturing in the automobile industry, for example, would undoubtedly be a step backward.

Manufacturing and production orders were discussed in preceding chapters. Such orders are necessary when relatively small quantities of different products must be manufactured intermittently. Some form of order control of production must be applied in such cases. Continuous manufacturing, however, deals with the continuous flow of production from each production center, whether it be a machine or groups of machines that are united by some conveyor to form a production line. If this stream were to be broken into small lots and the production of each lot were to be controlled individually, the control problem would be complicated tremendously. The expense would be increased accordingly. Therefore the type of control that is applied has been called "flow control." It is based on the maintenance of a predetermined rate of flow of work from each machine or work center. This rate of flow must be properly correlated with the rate of demand for the products. Inasmuch as the fundamental principle is different, we must expect to find quite different control techniques. The various principles of flow control can be illustrated by the control methods of a well-known automobile manufacturer. The principles are generally applicable to any highly continuous manufacturing concern, but the particular procedures are valid only in our illustration. Furthermore, another automobile manufacturer might develop other methods of applying these principles that would produce equally good results. Inasmuch as most automobile concerns are very large, it is necessary to look briefly at certain characteristics of large corporations that affect the control problem.

The Operating Structure of the Large Corporation

The large corporation may be the result of a horizontal or a vertical integration of manufacturing establishments, or both. The various elements in its corporate structure may have been acquired by purchase, consolidation, or the organization of independent divisions. These divisions may be located at strategic points throughout this country, and perhaps in many foreign countries. The objectives of such geographical decentralization are better customer service, lower transportation charges, lower inventories, and other values. The general offices of the corporation may be located in some great city like New York, Detroit, or Chicago; its principal operating divisions may be some distance away. Some of these divisions may be incorporated separately, in which case the parent concern is a holding as well as an operating corporation. The principal executive of the division may have the rank of president or general manager, depending largely on its size and corporate status; he may also be a vice-president in the parent company.

There is a strong central administrative control in most large successful corporations. The application of such control is confined largely to the interdivisional coördination of operations, however. This policy rests on the distinction between a strong central authority and decentralized control made earlier in our discussion of the economics of organization. The general executives of the corporation, with the assistance of their staff executives, handle such problems as the determination of general corporate objectives and policy, long-range planning, corporate financing, interdivisional relations, and similar matters. The central staff agencies may aid in the solution of such problems as the integration of corporate purchasing power, the correlation of engineering developments, or the introduction of uniform accounting methods. These agencies may assist in the solution of any other problem affecting more than one division, in which recourse to impartial, central, highly trained counsel is of value. As a rule, each division is expected to work out solutions for its own problems. In most cases, it is reasonably accurate to think of the central staff executives and their subordinates as permanent consultants to the operating divisions. They maintain a strictly staff relation with them. While these staff executives have no authority to compel the division's executives to accept their advice, their prestige is usually sufficient for their advice to be followed unless local conditions make it clearly inadvisable. For example, it is likely that a division must conform to some broad, basic

classification of accounts, and follow certain corporate accounting policies. But within these broad limitations, the details of its accounting procedures are strictly up to the division comptroller; the comptroller's staff at the general office may advise, but it cannot order, even when it considers a particular procedure poor practice. The headquarters comptroller can always take up the matter with higher line authority, however, when there is a violation of corporate policy and standard procedure. It is usually unwise for a headquarters staff executive to do so, however, before an effort has been made to get a meeting of minds at the divisional level.

As a result of this divisional autonomy, the president or general manager of a division may have almost as much freedom of action as the president of an independent concern. The division must present its plans at the beginning of the manufacturing year, and must work closely with the general offices in their development; it must make such reports as may be required for administrative control. The divisional and general offices of the corporation may be connected by teletypewriter, over which information flows constantly. Still there is no centralization of operative control. Once the division's objectives and plans have been approved, the control of its operations may rest almost entirely in its hands. It would be extremely difficult to hold its executives accountable for results if this were not so. Of course, the president of the corporation cannot avoid his ultimate responsibility for operations by delegating it. However, he rarely interferes in the operations of a division, except in a serious emergency. He should then put the situation back on a decentralized basis at the earliest possible moment. This decentralization usually extends downward from the general offices of the corporation, through the general offices of the division, to the offices of the plants composing it; there, however, the picture may change. Operative production control within the plant may be highly centralized when we have conditions of continuous manufacturing. The explanation rests on certain principles of centralization that have been noted previously.

The structure of the organization in Fig. 6.1 could be suitable either for intermittent or continuous manufacturing. The structure in Fig. 15.5 would be suitable chiefly for a plant that is engaged in intermittent manufacturing. It will be recalled that control was decentralized in the latter case. A foreman has chiefly the line functions of control with continuous manufacturing. The staff control functions usually are centralized in the plant production control office.

The Relations of Demand and Production Policy

It has been seen previously that the relationship between demand and manufacturing policy directly affects such problems as plant layout, equipment purchasing, budgetary control, etc. It affects also the problem of production control in continuous manufacturing. It is practicable to manufacture continuously to stock, under certain conditions. This is more likely to be the case when the product is a consumer convenience good that has small unit bulk, a low unit cost, a low style factor, little danger of spoilage and depreciation. It is usually more practicable when the product is not subject to rapid technological change and obsolescence. There are lesser degrees of product and market stability, of course. These indicate usually less ability to regularize production and employment by continuous manufacture to stock. The principal advantages of this policy are relatively lower investments in plant and equipment, a smaller working force, steadier production and employment, lower unit costs, and higher morale. Its disadvantages are relatively large inventories and low inventory turnover, and certain others. There is the hazard of excess inventories. There is the danger of inventory depreciation during a business recession. It is evident that employment instability rather than stability may result unless a proper relationship between forecast demand and the rate of manufacture to stock is maintained. The policy of manufacture to stock is desirable where practicable, however.

It may be necessary, on the other hand, to manufacture directly to the demand curve when the conditions for successful manufacture to stock are not present. This policy has the advantages of relatively low inventories and a high turnover of working capital. However, the investment in equipment must approximate the capacity requirements of the anticipated peak load per shift. Labor turnover tends to be high and employee morale relatively low. It is evident that business forecasting is an important factor in both cases, inasmuch as it provides information vital to the accurate determination of production programs.

Manufacture directly to the company's demand is more typical of the kind of industry that has been selected for discussion purposes. Such manufacture requires the maintenance of a continuous flow of materials to the various operations. This flow is correlated directly with and precedes slightly the scheduled flow of production from these operations. The flow of production must in turn be correlated directly with and anticipate slightly both the forecast and the actual demand for the products.

The Production Program

Whether the product is manufactured continuously to stock or directly to demand, the production program must be based on the forecast sales volume. Since statistical forecasting techniques are not highly accurate, sales forecasts are usually a combination of statistical analyses and coördinated opinions from the field, modified by the judgment and experience of the company's executive committee or whatever group passes on the final estimate.

When a concern is working directly to demand, the sales and production programs tend to be identical, or at least quite similar. A production program for this type of manufacture is shown in Fig. 17.1. About the middle

PRODUCTION PROGRAM

RECOMMENDED:____________ V. P. Mfg. DATE RELEASED:____________

RECOMMENDED:____________ For Exec. Com. APPROVED:____________ Pres. & Gen. Mgr.

Models	February		March		April	
	Act.	Cum.	Act.	Cum.	Act.	Cum.
A	10,000	40,000	15,000	55,000	20,000	75,000
B	15,000	75,000	11,000	86,000	10,000	96,000
C	7,500	33,000	12,000	45,000	19,500	64,500
Etc.	Etc.	Etc.	Etc.	Etc.	Etc.	Etc.

Fig. 17.1. A Production Program for Continuous Manufacturing

of the preceding month at the latest, in this case January, the central control office of the division will receive a copy of the program. It will give the estimated production requirements for each model for the coming month, and for the two or three succeeding months. However, the divisional production organization is held responsible only for the production required in the coming month, February; The sales division is responsible only for its distribution. The forecasts for March and April are tentative. These forecasts are included to give advance information as to expected trends. These programs through the manufacturing year embody the results of a series of "rolling," or "overlapping" short-range forecasts. An annual forecast was probably made at the beginning and middle of the

manufacturing year. The concern had the benefit of at least four "scientific guesses" before it made its forecast for February. This accounts in part for the high forecasting efficiency of some concerns. It will be noted that the monthly sales and production requirements are stated in terms of both actual totals needed for the current month, and cumulative totals from the beginning of the manufacturing year to the end of that month. It is the cumulative total that controls. The problem is to correlate a continuing flow of materials and production with a continuing flow of demand. If only 9500 units of Model A are produced in February, 15,500 units will have to be turned out in March, provided, of course, that changing business conditions do not force a modification of the forecasts. A cumulative total is usually the statistical type that best represents continuity.

When the program has been approved by the principal administrative executive of the division or his delegate, it becomes an operational order authorizing the production of the finished product for the coming month as shown. The program plays an important part in the coördination of activities. Copies will be distributed, therefore, to the sales, manufacturing, purchasing, and budget departments, and to any other subdivisions of the organization that need them.

Routine Planning

The central control office of a large factory such as we are discussing probably will extend its control only to the plant office. The central office will be concerned largely with regulating the rate of the flow of parts and subassemblies between plants and to the final assembly plant. This modifies considerably the kind and amount of information required for control purposes. The central control office may maintain card records showing the name and number of each part or subassembly, the models that use it, the number of pieces needed for each model, its interplant routing, the factory float required for each plant that participates in its manufacture, etc. Once these records are set up, little reference may be made to them in scheduling and dispatching production to the various plants. This information, and other instructions concerning what is to be done, how and where it is to be done, etc., are sent to the plant control offices at the beginning of the manufacturing year. It does enter into production control, accordingly. It is not necessary, however, to release such information to the plant offices whenever production schedules are sent to them. If any change in product or process is made during the year, the central office is usually responsible for seeing that the records of the

plant offices are corrected promptly. The principle that applies is this: when a series of like projects is executed continuously under standardized conditions, a given phase of control may be performed at one time for all like projects which are to be completed over a period of time. In large-scale, highly continuous manufacturing, the production of certain parts or subassemblies is assigned to certain plants. Once the necessary layout, tooling, and organizational changes have been made in these plants at the beginning of the manufacturing year, it is unlikely that product, process, or manufacturing conditions will be altered to any extent until the new models are brought out the following year. Equipment in these plants is set up for straight-line production and continuous assembly. This situation is quite different from the problem of routine planning with intermittent manufacturing. Detailed routine instructions had to be issued, in the latter case, with each order, even though the products were standard.

Factory Float

Before the problem of scheduling can be examined intelligently, the meaning of "factory float" must be clarified. This float is the amount of inventory of a material, part, or subassembly between two points in the flow of production, expressed in terms of time rather than quantity. Figure 17.2 illustrates this concept diagrammatically. Part X is made from a drop forging. On the basis of an analysis of manufacturing methods and conditions, it is estimated that 14,000 pieces will normally be in float between the shipping dock of plant A and the shipping dock of plant B, and approximately 6000 pieces between that of plant B and that of the final assembly plant, C. The factory is set up to manufacture this part at the rate of 2000 pieces per day. The total factory float between plant A and the shipping dock of plant C is

$$\text{Float A-C} = \frac{\text{Inventory in float}}{\text{Rate of production}} = \frac{20{,}000 \text{ pieces}}{2000/\text{day}}, \text{ or 10 days' float}$$

This means that approximately 10 days after a shipment of drop forgings for part X is sent from plant A to plant B for machining, the finished parts will leave the shipping dock of plant C, as an integral part of the finished product, for delivery to the customer or to temporary storage. All productive activities of every plant must be based on the rate of flow required

for each finished product from the end of the assembly line, as determined by the production program. This flow may be modified slightly from day to day in accordance with incoming orders. Float figures may be used to correlate the rates of production of all the plants which make or use a part, with the assembly plant's requirements for that part. For this reason these figures are usually based on the shipping dock of the final assembly plant.

Float time in continuous manufacturing is synonomous with lead time in intermittent manufacturing. Some executives use the terms interchangeably, in fact. A manufacturing assembly diagram can be drawn for

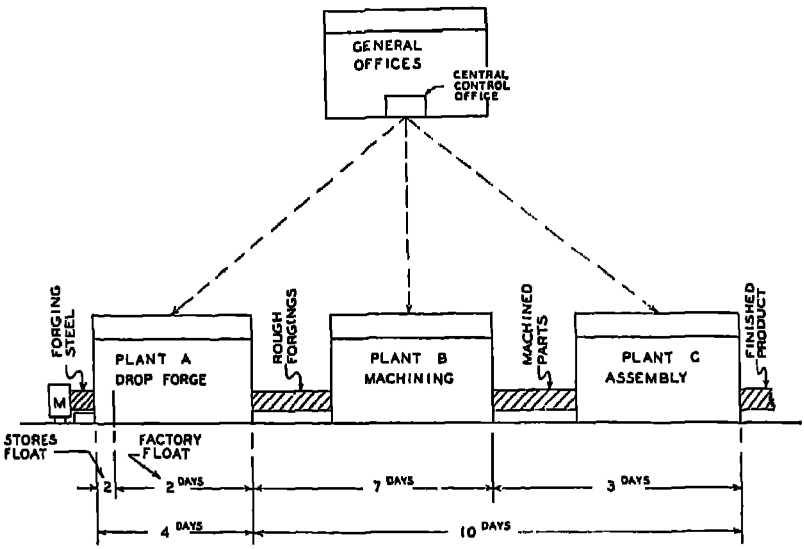


Fig. 17.2. Float Diagram, Part X

the continuous manufacture of an assembled product. This diagram will be similar in appearance to the diagram shown in Fig. 16.7. Let us assume that product 121 in this illustration is an airplane. Final assembly is continuous. There are 12 stations on the final assembly line. There is a single plane at each assembly station. The operation is planned to produce 2 assembled planes per day. The final assembly float time is 6 days, therefore, as shown in Fig. 16.7. It will be assumed further that production from the end of the assembly line has only been one per day, actually. So the actual float time is 12 days. The same condition exists in the subassemblies, and in some of the major parts. The initiation of procurement for both manufactured and purchased parts has probably been consist-

ently late in consequence. The result has been shortages of materials. They have been one of the causes of the low production rate.[1]

The concept of factory float is significant for other reasons than as a factor in control. A low float usually means a high capital turnover. It means also various economies that result from more effective use of equipment and labor. It makes possible greater speed and flexibility in servicing customer demands. The lower the float, the more business is likely to be done on the vendor's capital. For example, if the total stores and factory float for a given part were 2 days, it might be possible for a concern to receive a shipment of material from the vendor, process it, ship the finished product to a dealer, and discount his acceptance before the discount date of the vendor's invoice came due. Such a high turnover is actually accomplished in some plants for some items. It is not possible for most parts production, however.

A low float depends on good production and inventory control, a high rate of output, straight-line production, and a minimum distance for work to move between operations, the number of operations, and mechanical materials handling. The internal transportation system is particularly important; any means which insures the speedy, efficient movement of work —spiral gravity-roll conveyors, truck trains, etc.—may be used. These have been discussed previously in Chapter 11.

Scheduling

Scheduling in continuous manufacturing is the function of determining the rate of production for each part or assembly from each production center that is necessary to maintain the predetermined rate of flow of finished product from each final assembly line. The production program is a statistical statement of the amount of this flow over a period of time, usually one month.

The closeness of control varies directly with how close the controlling authority is, both physically and organizationally, to the operations to be controlled. This usually means that the period of time over which a release of authority operates becomes shorter and shorter as the point of primary operative performance is approached. This is necessary for flexibility in adjusting operations to interferences and changing conditions, as well as for close coördination. As shown in Fig. 17.2, there must be a central

[1] This is not entirely a hypothetical situation. The author encountered one that was very similar to it during World War II. The conditions were those of intermittent parts production with continuous assembly. It was a "hybrid" condition of manufacturing.

control office in the division's general offices. Since the period covered by the production program is too long for this office to control plant operations effectively, in most cases it issues a production schedule to each plant covering the deliveries required for a period not longer than one week.

To make such a schedule, it is necessary to break down the production program for finished products into an equivalent daily program, such as that shown in Fig. 17.3. To show how it is done, we shall assume that

PRODUCTION SCHEDULE

PLANT: A — WEEK ENDING: Feb. 3rd

PART: X — USED ON MODELS: A only

WORKING MONTH: 20 days — USAGE: 4 pcs./unit

Model	A	B	C				
Required	10,000	15,000	7,500				
Rate/Day	500	750	375				
Jan. 31	30,000	Units of	Model A,	cumulative requirements.			
Feb. 1	–						
" 2	–						
*Mon. " 3	30,500						
" 4	31,000	10 DAYS FLOAT					
" 5	31,500						
" 6	32,000						
" 7	32,500						
" 8	–						
" 9	–						
Mon. " 10	33,000						
" 11	33,500						
" 12	34,000						
" 13	34,500						
" 14	35,000						
" 15	–						
" 16	–						
Mon. " 17	35,500		X	4 - 142,000 pcs., cum. total required			
" 18	36,000			shipments, from Plant A			
	Etc.			to Plant B, up to and including			
	Etc.			Mon. Feb. 3.			

Fig. 17.3. Use of Float Relationships in Scheduling with Continuous Manufacturing

plant A's production schedule for part X, shown in Fig. 17.1, is being made; that it covers forging requirements up to and including the week ending February 3. This plant also makes forgings for many other parts. To simplify the problem, we shall assume that part X enters into the assembly of only one model of the product, Model A. The production program in Fig. 17.1 requires an output of 10,000 units of Model A during February, and a cumulative total of 40,000 units from the beginning of the manufacturing year. Consequently, 30,000 units should have been produced up to and including January 31. At the present time, the plant is running approximately 20 days per month. This means that product A

must be assembled at the rate of 500 units per day, approximately. On this basis, the daily production program can be extended from January 31, as shown in Fig. 17.3. Inasmuch as plant A has a 10-day float for part X, any forgings shipped from it to plant B up to and including February 3 will not be shipped from plant C as component parts of Model A until February 17, when the cumulative total requirements will be 35,500 units. To service this volume, plant A must ship to plant B a cumulative total of 142,000 pieces of part X by February 3, because each unit of Model A requires 4 pieces of part X. This quantity will appear on plant A's schedule of shipments to plant B.

The scheduling problem, however, is more complicated than might be suggested by the above example. It has been assumed that manufacturing will be carried on at a constant rate throughout the month; but frequently this is not the case. When the program is accelerated or retarded, factory float becomes extremely important in determining the proper time coördination between the production rates of the various plants. Furthermore, it is economical to make parts interchangeable between models wherever possible; part X is more likely to be used on a dozen models than on Model A only. In some cases, there is interchangeability between lines of product as well as between models. It is also necessary to take account of scrap, the requirements for service parts, and the assembly needs of other divisions of the corporation that may use part X. The large volume of materials to be processed and moved may modify the schedule. Nevertheless, scheduling is much simpler than it is with an order control of highly intermittent production. The methods described here are based on the practices of a concern that normally employs between 20,000 and 25,00 employees; the factory includes over 15 plants located on an area of about 1½ square miles. In spite of this size, one comptometer operator in the central control office formerly worked out all interplant schedules for these plants. There are other people in this office, of course, who are concerned with other phases of control. The central control procedure has been modified, in recent years, to adapt it to the use of electronic tabulating equipment. The objective of the change was faster handling of paper work and lower office expense. The general principles and methods of attack are still the same, however.

Preparation

It might appear at first glance that the preparation function has been reduced to insignificant proportions, if not largely eliminated; but this is not the case. Here is merely another example of the principle of continuous

control that we noted in connection with routine planning. A continuous integrated activity is carried on under highly standardized conditions. Sufficient machine capacity is provided at the beginning of the manufacturing year when plant layouts are changed to meet the requirements of the new models. Each plant has an efficient machine repair service equipped to relieve promptly most production interferences due to machine breakdowns. For these reasons, it is not necessary for the central control office to check the availability of equipment when releasing schedules; the effect of schedule changes on hours of work may have to be checked, but the plant manager's office may be responsible for this.

In some operations, such as automatic drawing-press operations in cartridge manufacturing, tool consumption is both high and continuous; and in such cases, the central control office may submit a tool production schedule to the tool division just as it does to the primary productive plants. Tools may be delivered, as produced, to central tool stores, or direct to plant tool cribs near the machines concerned. In other cases, tools may be carried in central tool stores on a maximum-minimum basis; when this is done, the central control office should check inventories of the tools required, if the schedule is changed to any extent.

A change in the rate of production of finished products involves a change in the rate of delivery of raw materials and purchased parts. Purchase delivery schedules often are made out by the central production control department and submitted to the purchasing department for execution. The method of making such schedules requires merely a slight modification and extension of the technique of scheduling production. When they are approved by higher line supervision, they carry the necessary authority to buy. In some cases, however, these delivery schedules are worked out in the purchasing department from a copy of the production program. This is a less desirable procedure for reasons that will be made clear when we consider the function of purchasing.

In all these instances, the assurance that proposed schedules can be met has required assurance that the various factors in performance will be present when and where they are needed, etc. This in turn has required the coördination of the facilitative services of certain technical staff functions with the activities of the primary line organization—the principal function of preparation. However, the preparation functions, like routine planning, for continuous manufacturing, can be done at one time for all like projects which are to be executed over the period covered by a production schedule, or longer. For example, the performance of the preparation function is unnecessary every time a truckload of castings is delivered

to the head of a production line. The elimination of much detailed work has in no way reduced the importance of the function, nevertheless.

Dispatching, Direction, and Supervision

Dispatching, which is quite routine, has to do with the weekly release of schedules to the various plants. The plant managers operate, of course, under the direction and supervision of the general manager.

Comparison and Corrective Action in the Central Office

One of the objectives in production control is the maintenance of the required rate of flow of parts, assemblies, and finished products from the various plants. Therefore the cumulative totals of the shipments required from each plant become the performance standards for comparison purposes. The central control office may receive from each plant a copy of its daily shipping report, showing the amount of each part or subassembly that has been moved to other plants, and also a copy of its scrap report. The office may enter these figures on some recording device, such as a production ledger, chart, or control board; but whatever the device, it should facilitate comparison of cumulative actual shipments with the cumulative totals of scheduled production.[2] If a plant's output of a given part falls below its scheduled production by more than the permitted allowance, the matter may be brought to the general manager's attention by his copy of the daily shortage report; another copy is sent to the plant manager. The general manager is responsible for taking whatever corrective action seems necessary. The top line executives of the division also receive reports that give interplant comparisons of sales, budget performance, cost ratios, and other measures of economy and effectiveness at the level of major operative management.

No attempt to go into detail has been made. It should be evident, nevertheless, that the functions of comparison and corrective action break down into the same fundamental phases for production control with any type of manufacturing.[3] The details of performance are quite different.

Plant Production Control

Production in a given plant is controlled by the plant manager with the assistance of his own staff control organization in the plant office. Inasmuch as management is decentralized between the divisional office

[2] The graphic application of these relationships is shown well in the Gantt chart for continuous manufacturing. See Wallace Clark, *The Gantt Chart*, The Ronald Press Company, 1922.

[3] The fundamental phases of control were discussed in Chapter 5.

and the plant office, the plant manager must perform all the organic functions of major operative management. He may be completely responsible for the accomplishment of plant objectives. This is quite likely to be the case when managerial and operative decentralization have been made on a product-line, profit-center basis. A complete responsibility, in such case, would include the accomplishment of the plant's primary service objectives, in conformity with the requirements of quantity, quality, expense, time, and profit. Production control is usually centralized, however, between the plant office and a directly productive department. Some of the controlling principles are these: the degree of centralized control that is most effective and economical varies directly with the degree of standardization that can be developed and maintained, and with the speed, capacity, and accuracy of communication methods. It varies directly, in a plant, with the degree of mechanization that is practicable and the consequent transfer of skill and knowledge to the machine.[4] The conditions necessary for continuous production and assembly conform to these requirements for centralized control. It should also be remembered that we are now much closer to the point of primary operative performance, where a much closer control of production is required. As a rule, the weekly schedules issued by the central control office must be broken down by the plant production control office into daily runs for each production or assembly line; in some concerns the plant office makes hourly releases. The central control office usually stands strictly in a coördinative staff relationship to the plant production departments. The effect is to centralize control in the hands of the plant manager.

The Control of Production Lines

When the volume of busines is sufficient to permit setting up equipment for straight-line production, the division of executive responsibility and authority in the plant tends necessarily to be based on the characteristics and manufacturing requirements of products. To return to Fig. 17.2, there will be a production line in plant B for the machining of part X. We shall assume that this part is the camshaft of an automobile engine and that the particular production line is shown in Fig. 17.4.[5] This department may be under the direction of a foreman and one or two assistant foremen.

[4] We have commented previously on the development of complete automation for some operations in some industries. A closed-loop system requires centralized control. It does not, however, require the use of electronic computers.

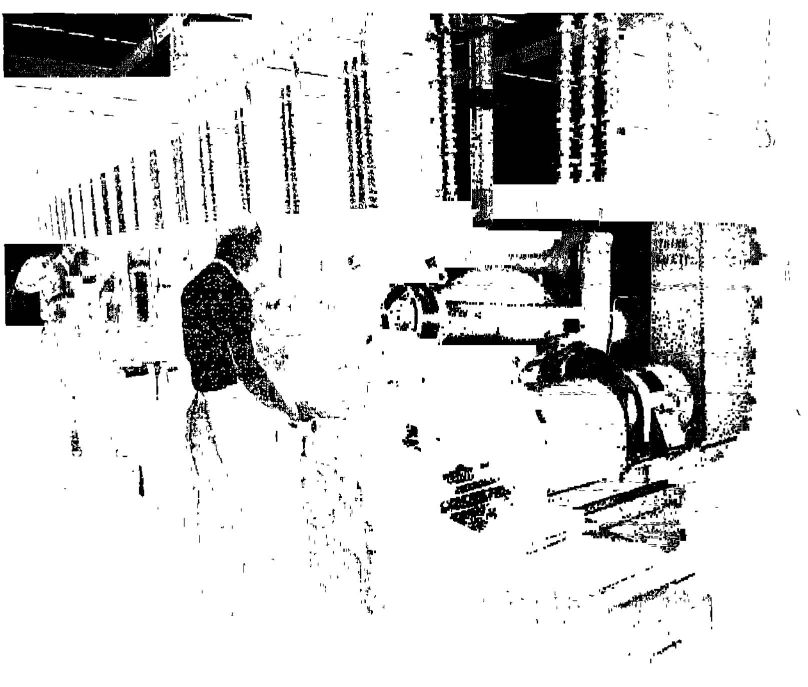
[5] The contrast between Figs. 17.4 and 17.5 is interesting. Figure 17.4 shows a present-day line set up for continuous operation, but that cannot be fully automated. The company has fully automated lines similar to that in Fig. 10.7, however. Figure 17.5 shows a production line in use about 20 years ago.

A conveyor carries the forgings from one operation to the next.

The principle of control of continuous production may be illustrated by Fig. 10.9, which we shall again assume to be the camshaft line. When material is moved to the head of the line, the only place it can go is down the line. Theoretically, and most of the time actually, it flows along the conveyor from operation to operation, much like water through a pipe. This is due to the highly standardized, conveyorized, and balanced condition of production. There is no danger that production will be held up because of conflicts in requirements of orders for machine capacity, or that an order will arrive in the wrong department because of the vagaries of an unintelligent trucker, or that other troubles found in an order control of intermittent production will occur. It follows that control of the flow of material to the head of a production line also controls the flow of worked material from the end of that line.

To apply this principle it is necessary to break down weekly schedules into daily runs for each part, and these in turn must be broken down into schedules for the delivery of materials to the lines that make each part.

Fig. 17.4. A Camshaft Production Line, Using a Power-Driven Monorail Conveyor. (Courtesy, The Ford Motor Co.)



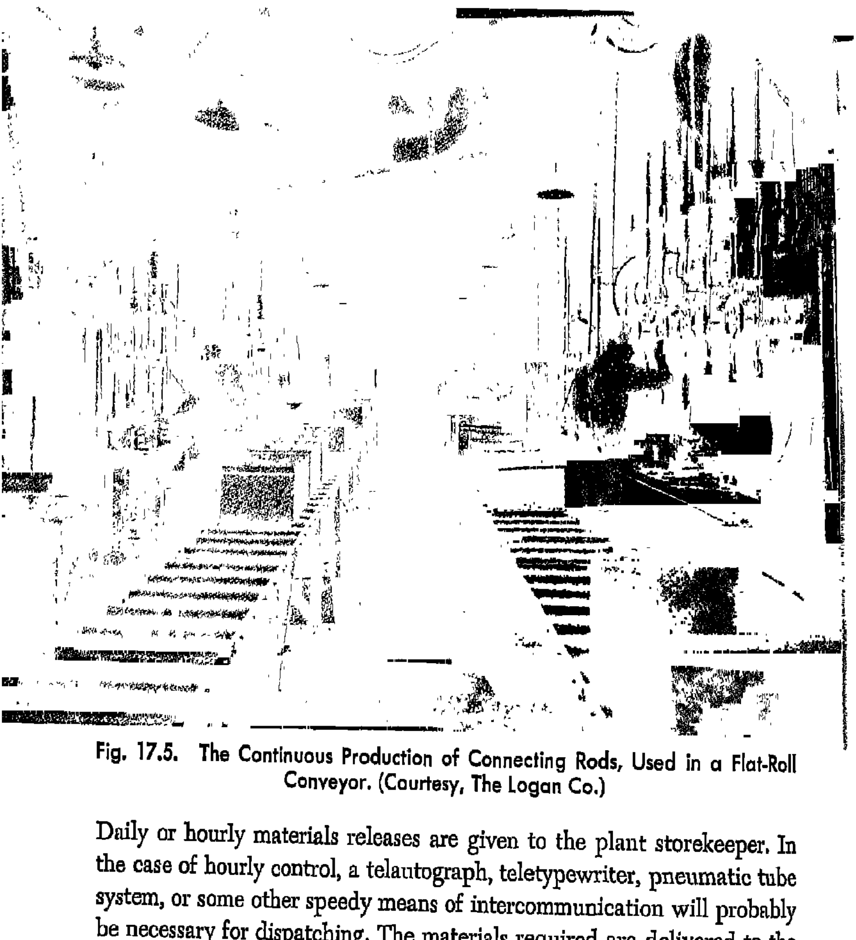


Fig. 17.5. The Continuous Production of Connecting Rods, Used in a Flat-Roll Conveyor. (Courtesy, The Logan Co.)

Daily or hourly materials releases are given to the plant storekeeper. In the case of hourly control, a telautograph, teletypewriter, pneumatic tube system, or some other speedy means of intercommunication will probably be necessary for dispatching. The materials required are delivered to the banks of work at the head of each production line by battery-truck trains or conveyors from the plant storeroom. Trucks usually run on a definite schedule based on the quantity of materials and the frequency of delivery necessary to meet the requirements of the various lines.

It will be seen that the plant office may directly control this camshaft line by means of its control of the delivery of forgings. Hence this is a centralized control of production, within the meaning of our use of the term.[6] The foreman of the department has little or no direct control of the rate of production; but he does influence it indirectly and considerably, through his supervisory, disciplinary, training, and other activities. The centralization of production control leaves the line department manager, the foreman, with only the line phases of control. He remains responsible

[6] To avoid giving the impression that the principles of continuous production and its control apply only to assembled metal products, we refer the reader to Fig. 11.2, which shows continuous production in a Chicago pie factory.

for the production of the required quantity in conformity with quality standards. The foreman may have little control of and responsibility for departmental operating expense. His position of leadership may be weakened by a centralized control unless measures to support it are taken by higher line authority. The foreman's ability to maintain the morale of his operatives may be weakened accordingly. This may create a dangerous situation when we are dealing with a strong union. Some of the steps to rebuild the foreman's leadership position, that have been taken by some large companies, will be discussed later, in connection with the problem of organizational morale.

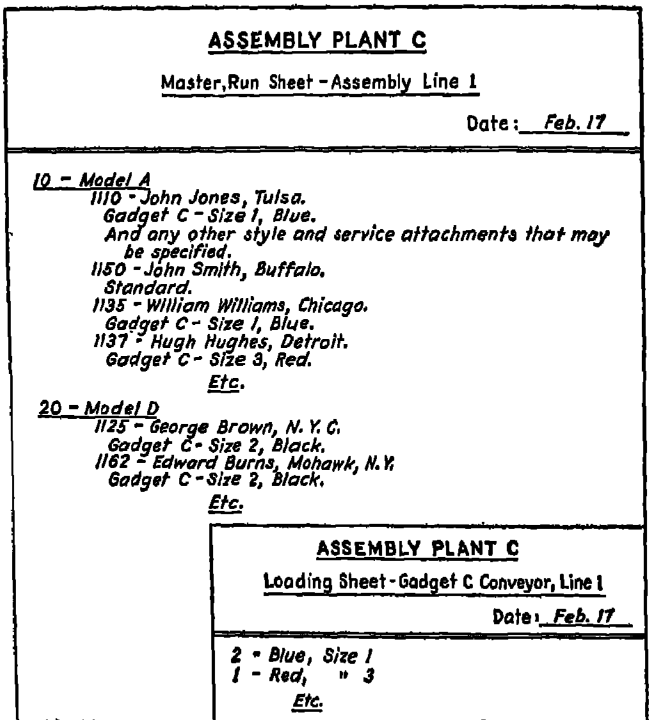
The comparison function in the plant office necessarily must be based on the flow control concept. The plant storeroom reports its disbursements of materials to each production line. As work comes off the end of the line, it is either inspected on the spot or moved directly to central inspection points. The inspectors turn in reports of the amount of good work and scrap to the plant production control office. The plant shipping department reports the quantity of the particular part that it has moved to the parts and service division, to the central shipping department for shipment to another division or another plant of the corporation for further processing, or to the final assembly plant. This information is recorded in cumulative totals. The difference between the total releases and the deliveries from stores is, of course, the amount authorized for further delivery; that between deliveries from stores and the production reported is the bank of work in process and ahead of the line; the difference between reported production and shipments is the bank of finished parts ahead of the shipping floor. Availability for shipment is dependent on quality inspection, of course. Standard float figures should be available for each of the above breaking points. The computation of the actual floats represented by these banks is quick and simple. Comparison of these two indicates clearly and accurately the status of production for the particular line. A comparison of the actual and the scheduled cumulative total shipments from the plant shows where it stands currently with regard to the central office schedule. The foreman is expected to report promptly any holdups in production; and these, together with shortages, are reported periodically to the plant manager. The reporting of production holdups may be mechanical when a production line has been completely automated.

The Control of Continuous Assembly Operations

The problem of controlling continuous assembly operations often presents some interesting phases because of the influence of the product's

style and service features and the customer's demands for deliveries. The production program must be the controlling factor, ultimately; it is the basis of the coördination of fabrication and assembly operations. The customers' orders, on the other hand, must be filled as promptly as possible, and in the order received.

The assembly plant office will probably receive from the sales department copies or lists of sales orders covering individual sales to customers



ASSEMBLY PLANT C

Master Run Sheet - Assembly Line 1

Date: *Feb. 17*

10 - Model A
1110 - John Jones, Tulsa.
Gadget C - Size 1, Blue.
And any other style and service attachments that may be specified.
1150 - John Smith, Buffalo.
Standard.
1135 - William Williams, Chicago.
Gadget C - Size 1, Blue.
1137 - Hugh Hughes, Detroit.
Gadget C - Size 3, Red.
Etc.
20 - Model D
1125 - George Brown, N. Y. C.
Gadget C - Size 2, Black.
1162 - Edward Burns, Mohawk, N. Y.
Gadget C - Size 2, Black.
Etc.

ASSEMBLY PLANT C

Loading Sheet - Gadget C Conveyor, Line 1

Date: *Feb. 17*

2 - Blue, Size 1
1 - Red, " 3
Etc.

Fig. 17.6. The Principle of a Master Run Sheet and a Loading Sheet for a Feeder Conveyor

or dealers. These orders will be scheduled for production approximately in the order received. Orders will be grouped together on the basis of similarity of styles and models as far as possible, so that production on the assembly line will be as homogeneous as possible. Each day the assembly plant office may list the styles and models to be assembled on the following day in the order in which they are to be run. The number of each sales order and other identifying information is listed under each model, and under each order number the particular style and service

features specified by the customer. This list, an example of which is shown in Fig. 17.6, becomes the assembly program for that day, or the "master run sheet," as it is sometimes called.

As a rule, continuous assembly requires that there shall be a base piece to which other parts and subassemblies can be attached as it goes down the assembly line; in automobile assembly, the piece is the frame of the car. The base pieces for different models of the same product need not be identical, but they should be sufficiently similar in function and design so that they can be handled by the same conveying methods. This is particularly true when some form of power conveyor is used. However, when more flexible means, such as a hand-operated conveyor, must be used because of lack of volume, or variety in product characteristics, this requirement becomes less binding, but it always holds in some degree. Models handled on the same assembly line should also be sufficiently similar to permit a satisfactory balance of capacity between assembly groups.

The control of assembly is similar fundamentally to the control of a production line. The assembly plant office orders out the base pieces for

Fig. 17.7. A Platform Conveyor Serving Assembly, Crating, and Shipping Operations. (Courtesy, The Logan Co.)

the various models. These are delivered by the plant stores to a bank of parts and supplies at the head of the assembly line as shown in Fig. 17.8. The men at this loading station must start the pieces on the line in the order specified by the master run sheet. A tag may be attached to each piece showing the order number for which it is intended, the dealer's name, and any other identifying information, as well as the particular style and service features that the customer has specified. As the piece travels to and through the successive assembly stations, each assembler attaches the particular parts for which he is responsible. These parts may be stored in racks or trays representing small banks in back of the men

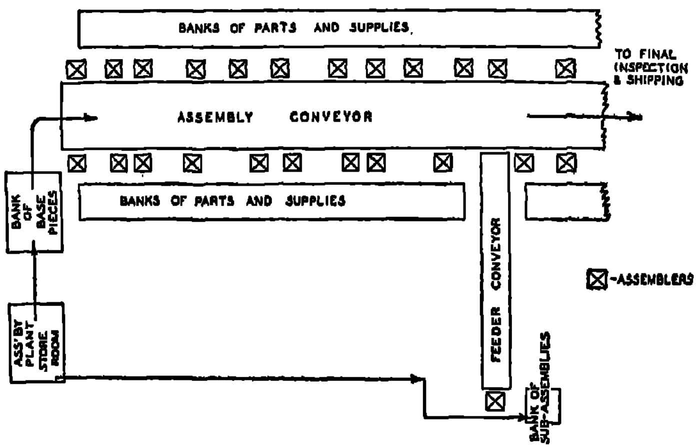


Fig. 17.8. Continuous Assembly Diagram

as shown in Fig. 17.8. The parts must be so placed that the parts or supplies can be grasped easily and quickly. In light assemblies, these pieces may be handled by overhead carrousel conveyors like that in Fig. 11.7. If special parts are needed for special jobs, or if the same part has different designs for different models, the identification tag on the product tells the assembler what to use. The popular picture of an assembly line as a place where a man puts nut 37 on stud 42, hour after hour, day after day, is greatly overdrawn in most cases.

The control of subassemblies presents a related but slightly different problem. The supply of a given subassembly to the line must be coördinated properly with other assembly operations. When the frame of a new car comes to the body assembly station, a green body should drop on green wheels and the body should be for a two-door sedan, if this is what the customer has specified; he would undoubtedly refuse to accept deliv-

ery if a red four-door model were put on the green wheels. To achieve this coördination, the master run sheet is broken down into "loading sheets" for each feeder conveyor for each major subassembly. We shall assume that the feeder in Fig. 17.8 handles gadget C which is used on Models A, B, D, and H, and that the customer may specify different sizes and colors. According to the master run sheet in Fig. 17.6, for February 17, ten units of Model A are to be run first, followed by 20 units of Model D, etc. Order 1110 calls for a unit of gadget C, size 1, blue. The next order, 1150, which is strictly standard, is followed by 1135, which also calls for a size 1, blue gadget C, etc. From this information a loading sheet can be easily set up for the feeder conveyor that handles gadget C. These subassemblies are ordered from the plant storeroom by the assembly plant office on the basis of this loading sheet, and delivered to a bank of these pieces at the head of the feeder conveyor. If the workman loads his conveyor in the order specified by his loading sheet, the right gadget has to be at the gadget assembly station when the right base piece arrives. But he must know his stock of assemblies thoroughly, and follow his loading sheet exactly: If the workman puts the right pieces on his conveyor in the wrong order, he will soon tie up the whole final assembly line.

When discussing coördination as a problem in the economics of control, we said that its two principal elements are time and the order of performance of the various phases of the project. In the present instance, the projects to be undertaken and their order are established by the master run sheet. The order for certain subprojects, supplying gadget C, is established by the loading sheet. The time factor is determined by the speed of the conveyor and the normal rate of production of the assemblers. In this comparatively simple manner, the fundamental requirements of coördination are provided for in a situation that appears extremely complex to the average visitor in a modern continuous assembly plant. The actual situation is much more complex than this discussion indicates, of course, because of the great amount of detail that must be handled. The procedure has been oversimplified to make clear the principles involved. Principles are the important consideration, because procedures frequently become obsolete in a few years.

Final Inspection, Packing, and Shipping

In continuous assembly, the finished product frequently travels on the assembly conveyor through final testing, inspection, and packing, to the shipping floor without stopping. Figure 11.8, showing the end of a refrigerator assembly line, illustrates what is meant. The relation of this

practice to maximum turnover of work in process, use of factory floor space, internal transportation costs, etc., has been discussed previously.

Other Applications of Continuous Assembly

The discussion has been based largely on the continuous assembly of mechanical products in large plants. The fundamental methods and principles of continuous assembly and its control may be applied also in small plants making nonmechanical products. It is merely required that we have sufficient volume, standardization, and the other requisite conditions mentioned above. Complete standardization, in the popular sense, is not needed, as we have seen. In small plants where assembly requires largely hand labor, continuous assembly is more easily developed than continuous production. It is easier to differentiate manual operations and get a functional balance between them, than it is to differentiate and balance mechanical functions. Figure 17.9 is a cross-sectional view of a packing table

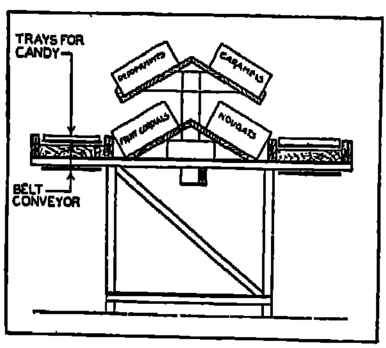


Fig. 17.9. Cross-Sectional Diagram of a Packing Table for the Continuous Assembly of Candy Assortments. (Courtesy, Link Belt Co.)

by means of which the principles of continuous assembly have been applied to the packing of confectionery assortments. The boxes of bulk confections are placed conveniently before the packers on sloping shelves, each packer handling one or only a few different confections. The candy boxes to be packed travel from one packer to the next on a flat-belt conveyor; each packer puts the required number of pieces in the proper position in each box, depending on the assortment that is being put up. When the box reaches the end of the conveyor, it is completely packed. A view of this installation is shown in Fig. 17.10. The installation enabled the same number of packers to handle nearly three times the volume that had been handled previously.

Fig. 17.10. A Packing Table, Showing a Flat-Belt Conveyor in the Continuous Assembly of Confectionery Assortments. (Courtesy, Link Belt Co.)

PROBLEMS

1. The scheduled production of Part 1085 is 6000 pieces per day. The plant production records show the following figures for this part, expressed in cumulative totals:

Deliveries of forgings to the plant	106,500 pieces
Plant storeroom shipments to the production line	91,220
Production line shipments to the inspection center for the part	90,058
Deliveries by inspection to the plant shipping floor	84,418
Shipments to the final assembly plant	83,656

The forgings are purchased from a local concern controlled by this company. To get the maximum practicable turnover, the production manager's office has established the following standard floats in the plant for this part:

Stores	2 days
Production	2 hours
Inspection	2 hours
Shipping	2 hours

These floats have been accepted by the plant manager. The plant works 8 hours per day and 5 days per week.

(a) At what points in the flow of production for this part may it be necessary for the plant management to take action?

(b) What organic function of control does this problem deal with chiefly?

2. Part 1650 is machined in Plant B, the entire production of this plant being shipped to Plant C for subassembly. For this Part Plant B has an 8-day float on the shipping dock of the final assembly plant. Model 12 of the product requires 5 pieces of this part per unit, and Model 18 requires 7. The production program for the current month calls for a cumulative total production of 76,000 units of Model 12 and 27,000 units of Model 18. The program for the following month calls for a cumulative total of 86,000 units of Model 12, and 33,000 units of Model 18. The first of the coming month falls on a Monday. The plant will work 5 days per week and a total of 20 days during this month.

   (a) What is Plant B's production schedule for this part, in cumulative totals, for the week ending Monday the first?

3. A concern which manufactures equipment for one of the public utility industries uses a form of order control for its production control system. Its volume of production is large, but it is spread over a wide variety of products, some of which, however, have a relatively heavy and continuous demand. The management has been considering the possibility of the continuous production of these items.

   (a) What factors should be considered in determining whether it is economical and practicable to manufacture these items continuously?

   (b) What changes in organization and operation may be necessary?

CHAPTER 18 •

• Quality and Quality Control

Quality and Its Significance

THE primary service objectives of the business organization are necessarily customer values. These values must be supplied with due regard for customer requirements, as expressed in terms of quantity, quality, time, and cost. These objectives may be any satisfactions of certain needs or desires. The quality of a product is that combination of attributes which gives it some capability for satisfying certain customer needs or desires.[1] Quality attributes are those product characteristics that distinguish one product from another product when both are offered to the customer in satisfaction of the same or a similar need. The quality of the product is unsatisfactory when it is rejected by the customer in favor of a competing product, because its need-satisfying capability is insufficient. The product may be rejected for other reasons that also have to do with value. These reasons may be a price that is regarded as too high, an unsatisfactory delivery date, or others.

It is evident that quality competition is fundamental in a free economy. The customer is free to select that product which will best serve his needs, within the limits of his purse, or his credit. An economic good or service can usually command a premium price, when it has some unique properties that enable it to serve some customer need in a superior manner.[2] The development of such properties usually requires superior organizations for research, engineering design, manufacturing, and quality control. Increased manufacturing know-how enables us, eventually, to give the cus-

[1] The Oldsmobile Division, General Motors Corporation, published in 1950 a booklet *Oldsmobile Quality Control Program*. It quotes, on page 6, the definition of quality in Webster's dictionary: "The characteristics of a commodity regarded as determining its value."

[2] This has been called the "principle of uniquity." These unique properties tend to reduce the pressure of price competition. It is possible, with good product and process design, that the production costs do not increase proportionately with the increase in quality and price. The volume of demand is always a factor in unit costs, of course. The cost of improved quality will usually increase faster than price, beyond some point, however.

tomer the higher quality at the same or a lower price. It is for this reason that quality competition may be harder to meet than price or delivery. The latter are usually short-run factors in competition. Quality tends to be a long-run factor. It is therefore a basic factor in lasting business success. The late L. P. Alford recognized this when he stated as a principle of manufacturing: "The quality of manufactured goods is a variable with an upward trend under conditions of repetitive manufacture."[3] Practical recognition of this principle has been seen in the rapid development of product research and development since World War II.

Quality Control

A product designer may be able to specify exactly the extent and degree in which each quality attribute should be present in the product at each stage in its manufacture. It may be possible to create these attributes with a high degree of exactness in an experimental model of the product, under laboratory conditions. It may be impossible to create them exactly under manufacturing conditions for a number of reasons. It may be impossible to adjust the production equipment with sufficient accuracy. The equipment may get out of adjustment with use, through shock and vibration. The tools used by the machine will wear. Workmen are careless occasionally. The actual condition of a quality attribute will vary from its exact specification for other reasons. This is true whether the attribute is some chemical characteristic such as ability to release energy with a change of state, some electrical property such as conductivity, some physical characteristic such as dimension, or some aesthetic characteristic such as color. Quality is a variable, in any case, relative to some absolute criterion at any given point in time, as well as to some trend over a period of time. It is usually the responsibility of the product designer to determine for each quality attribute of a product the variance from the exact specification that is permissible. This permissible variance is known as "tolerance." We shall discuss it later. A quality variance that is greater than this tolerance is not permissible usually, because it may lower seriously the ability of the finished product to service the public, it may increase costs on later operations in the manufacture of the product, or it may cause other difficulties.[4] Some control of quality is necessary because of its variability.

[3] L. P. Alford, *Laws of Management Applied to Manufacturing*, The Ronald Press Company, 1928.

[4] Alford and Beatty say that ". . . quality is a variable, and when the permissible limits of variability have been stated, quality has been adequately defined for all practical purposes." *The Principles of Industrial Management*, rev. ed., Ronald Press Co., 1951, p. 423.

Quality control is the function of assuring that the quality attributes of a product, or some component part of it, conform to certain prescribed standards, and that the relationships between these attributes are properly maintained. Much has been written in recent years about SQC, statistical quality control. It has been defined as "a method of applying statistical techniques to the collection and analyzing of inspection and other data in order to achieve and maintain maximum economy in manufacturing processes."[5] An important function of control of any kind is the comparison of actual results with applicable performance standards. A standard is any generally accepted criterion. A quality standard is a criterion of the kind, extent, and degree in which a quality attribute must be present in a product to enable it to meet the customer's needs satisfactorily. It is usually expressd as a range of variance, or acceptability, as indicated above. Since there are degrees of acceptability, the function of comparison in quality control always involves measurement. It is an important phase of inspection, which is the function of determining for a given item or items, the extent to which the required quality attributes conform to the prescribed standards. "Gauging" is usually the shop man's term for this process of measurement. Its use in metalworking shops is frequently retricted to the measurement of dimensional attributes, in so far as quality is concerned. Appropriate measuring devices enable us to measure the kind, extent, and degree to which the required quality attributes have been built into the product. These devices must be able to do so within acceptable limits of error in measurement. Some quality control instruments are quite complicated. The tapered plug gauge shown in Fig. 18.1 is an example of a simple device whose use is quite common.

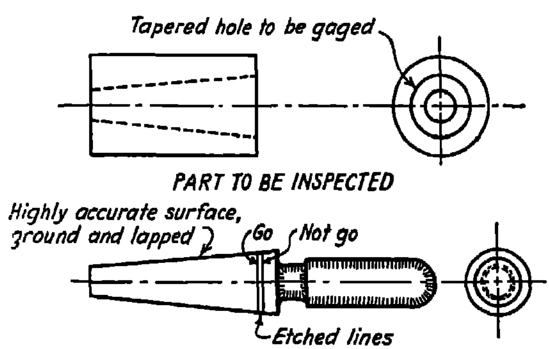


Fig. 18.1. A Tapered Plug Gauge

[5] W. B. Rice, *Control Charts in Factory Management,* John Wiley & Sons, Inc., 1947, p. 3.

Quality Control Objectives and Considerations

Properly organized quality control, exercised by a competent inspection staff, has a number of advantages. It results in greater uniformity of product and more dependable quality, a distinct advantage in distribution. To be successful, it is not necessary that a manufacturer produce the highest possible quality. It is most desirable for him to maintain the degree of quality invariably so that the public can have confidence that the quality will always be the same. Effective quality competition depends also on the manufacturers ability to give the customer maximum quality at the lowest price within the particular price class. The scrap problem is brought under control. By varying the strictness of inspection, the percentage of loss and rework can be controlled in the interests of economical production, within the limits set by the standards of quality. By indicating the causes of scrap, the inspection division can aid greatly in its reduction; this in turn means fewer interferences to production caused by the scrapping, replacing, or reworking of material, and a consequent increase in the ease and accuracy with which production is controlled. The costs of production are reduced. Quality control leads to improvements in the design of product and process. These improvements result in the production of the same or greater quality at lower cost. In the case of an assembled product, good quality control results in greater interchangeability of parts, and a reduction of assembly costs because the parts require little or no fitting. It happens frequently that the study of a quality control problem leads to the reduction of inspection costs without impairing quality. Furthermore, interchangeability provides better service for the customer since it enables prompt replacement of worn or broken parts without considerable fitting. The production of competitive quality tends to develop organizational pride and good morale. For these and other reasons, good quality control is essential to successful manufacturing.

Maintenance of the highest standards of quality consistent with economical manufacturing and the class of goods being produced does not necessarily mean a reduction in the plant's *per capita* production. In fact, many industrial executives believe that if quality is properly controlled, quantity will follow as a natural consequence. Wisely selected standards are educational in that they compel a company to select the best available methods, and guide it in applying them. Increased production follows naturally. It must be recognized that quality control methods can be refined beyond the point of diminishing returns. Obviously, unnecessary inspection and unjustifiably high standards of quality should be avoided.

This point varies with the nature of the manufacturing problem, and its determination is largely a matter of judgment and experience.

Effective quality control can be developed only from a careful analysis of the product and its attendant production problems, from the standpoint of the maintenance of quality. The quality of a product is limited usually by the quality of the materials from which it is made. This analysis should begin with the design of the product and the procurement of materials, and should cover every phase of production until the product is finally shipped.

A good inspection staff is a requisite for successful quality control. Quality is an intangible thing in many respects, and hence it is often difficult to measure and control. It is not exact and invariable. Quality deviations must be permitted in the interests of economy, but they must be controlled. The greater the permissible deviations from the quality standards, the greater the ease with which the production division can produce the desired output. To prevent such deviations from exceeding the permissible limits, there must be some department which is responsible for maintaining reasonable standards of quality. It watches vigilantly all deviations therefrom and takes the action necessary to prevent their persistence. Such a department is usually known as the quality control department, or the inspection department.

Administrative and Operative Controls of Quality

A distinction should be made between an operative control and an administrative control of quality. An operative control has to do chiefly with the determination of the quality of a specific lot or run of work. The inspection function is concerned primarily with operative quality control. Administrative quality control is concerned with departmental or group performance in maintaining the required level of quality for whatever products the group makes. It is concerned also with determining group effectiveness in raising the quality level where practicable. Administrative quality control involves usually interdepartmental and interdivisional quality comparisons, where they are valid. An administrative control of quality rests on an operative control.

The Responsibility for Quality

The kind and character of the various attributes of the product are determined by the engineering department. The skill and care with which the line production departments make the product determine the quality. This depends in part on the training given the operative force by its first-

line supervisors, and in part on the interest of the workmen in quality production. The latter is a function of employee morale. Effective leadership by the first-line supervision is a major factor in morale development and maintenance. Employee interest is dependent also on education for quality-mindedness. Good manufacturing equipment, well adapted to the work, is obviously an important factor in quality production. Thus cutting off a steel shaft to a given length, with a maximum variation of ± 0.005 inch, calls for a much more accurate tool than a hack saw. The control of these factors falls largely within the immediate jurisdiction of the line organization, and it should. As a rule, the one who produces quality must be responsbile for it. The production division therefore must be held primarily responsible for the quality of the product.

The inspection division is responsible for a thorough, exact comparison of the product with the applicable standards of quality. The division watches quality trends to anticipate and prevent the production of scrap and rework. It analyzes the causes of quality deviations. The inspection division should be held responsible for obtaining and evaluating prompt, accurate information that will enable the line organization to stop any losses resulting from quality failures. If a piece is machined improperly, all subsequent work on its is worthless. The inspectors should be the final authority in determining what work is standard and what is not. Furthermore, the inspection division should have the final decision concerning the extent to which the product is to be inspected after each operation. In some concerns an inspector may have authority to shut down a machine that is producing too much scrap. This is questionable practice, however. It is a direct interference with line responsibilities and authorities. Such interference relieves the foreman of quality responsibilities for which he alone should be held accountable.

The Organization for Quality Control

The effectiveness with which quality is controlled depends on the efficiency of the quality control organization. The extent of the organization's development and the design of its structure depends on the nature of the product and its quality requirements. Its effectiveness depends also on the volume of production. The organization shown in Fig. 18.2 is a further development of the company structures shown in Figs. 6.1 and 15.5. The chief inspector usually reports to the plant manager. He may report to the chief engineer in some plants, however. The product engineers have the staff responsibility for designing a product that will give the customer a competitive service, or better. These engineers determine

largely what shall be the quality attributes of the product. Product engineering has a direct interest, therefore, in quality standards and their maintenance. These engineers may accordingly set tolerances that are unnecessarily close, and insist on rigid adherence to them. Quality, on the other hand, is produced by the line organization of the plant. This organization has also a direct interest in quality and quality standards. It has

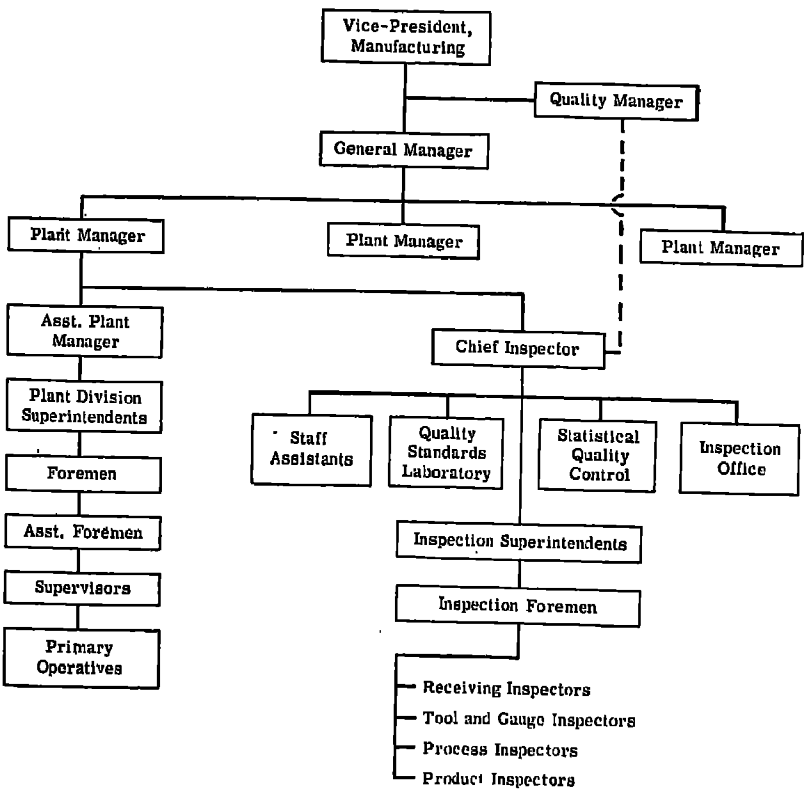


Fig. 18.2. The Quality Control Organization

in addition a strong interest in volume production, costs, work-in-process turnover, deliveries, and other problems. Minor operative executives may wish to open up the tolerances of a part, for a given operation, to get out production and hold down costs. The quality control organization is usually placed in an independent position in the plant organization because of these conflicting interests. The decisions of the chief inspector should not be influenced unduly by the desire of engineering executives for mechanical perfection, of sales executives for quality and quick deliv-

eries, or of operative management for quantity and low costs. The chief inspector may be subject to considerable pressure from these executives occasionally. His immediate superior, the plant manager, should have an overall view of the company's interests. This manager has the authority and prestige to enable him to back up the chief inspector effectively, when the latter is right.

In very small concerns, there may be no staff inspection at all. The operative employees of such a concern can often be indoctrinated with a philosophy of customer service, in which quality is strongly emphasized, to a much greater degree than is possible in a large concern; furthermore, their personal objectives can frequently be integrated with the company's service objectives through the development of certain personal satisfactions growing out of pride of craftsmanship.

The principal chain of command of the inspection division extends directly from the chief inspector, through inspection superintendents and foremen, to the department inspectors. In some cases, the latter may work individually or in small groups in the various production or assembly departments, and in others, in comparatively large groups in various central inspection centers or departments. Their work is the inspection of component parts at various stages in their processing, or the final inspection of major assemblies and finished products. The receiving inspectors are responsible for the comparison of all raw materials, supplies, and purchased parts with the standards that have been set up for them, in so far as this requires merely mechanical inspection. Samples may be sent to our engineering laboratories when chemical or physical tests are required. Such materials must be checked, particularly when they must conform to definite purchase specifications. As a matter of fact, the inspection function really begins with the inspection of raw materials. A quality job cannot be produced from subquality materials. A concern which produces and uses tools in large quantities may also have a group of tool and gauge inspectors. They are stationed in the tool department but they work under the general supervision of the chief inspector.

The supervisor of inspection standards is responsible for the accuracy of all instruments of comparison used by the inspection department. Many of them are constantly used for precision measurements of one kind or another. These instruments are subject to wear and other influences that may cause loss of accuracy, like any other device. Therefore such instruments should be checked periodically against master standards. For this purpose the inspection standards supervisor should have a standards or gauge-checking laboratory equipped with various high-

Fig. 18.3. A Quality Standards Laboratory. (Courtesy, The Packard Motor Car Co.)

precision measuring devices, and manned by highly skilled mechanics. In some plants, this group may also check the accuracy of tools, jigs, fixtures, and gauges, whether made by the tool department or purchased before their delivery to departmental tool cribs or to central tool stores. This is a secondary technical staff function, in the sense that it is a staff group that serves a staff function. It is a function of prime importance in quality maintenance, however. An example of such a quality control laboratory is shown in Fig. 18.3.

The statistical quality control group is concerned with the application of methods of statistical analysis to the control of quality. These methods will be discussed shortly. The objectives of this group are methods that will detect and anticipate adverse quality trends in the manufacture of a product before they cause trouble. It introduces and promotes the use of such methods where production conditions make them practicable.

The chief inspector may have one or more staff assistants who handle special problems in quality control and other duties that may be assigned to them. These assistants may analyze reports from department inspectors, and whenever necessary investigate the causes of continuing excessive deviations from quality standards. They may work with the product engineering, process engineering, and production divisions on methods of improving quality and decreasing scrap without lowering production.

Working with the personnel division, these assistants may develop better methods of wage payment, training, and promotion that will decrease turnover among inspectors and increase their efficiency. Some concerns may have a product committee which considers customer complaints as analyzed and presented by the sales department, trends in the development of competitors' products, etc., and makes recommendations to the executive committee in connection with new models. In such cases, the chief inspector and his assistants must work with this committee on problems involving quality.

The inspection office keeps the divisions records and assists the chief inspector in controlling its activities. It therefore performs a coördinative staff function.

A quality manager is shown reporting to the vice-president in charge of manufacturing, in Fig. 18.2. He is shown, in Fig. 6.1, as a member of the headquarters staff of the vice-president. This places him on a subordinate level of general administrative management. His duties accordingly have to do largely with interplant technical coördination in the solution of problems of quality production. The quality manager promotes the development of quality-mindedness throughout the company. He initiates company-wide policies for quality maintenance. He coördinates the development of quality-control procedures, where they have company-wide application. He acts as a consultant to the chief inspectors and their quality-control organizations. He performs other duties of a headquarters staff executive, but in the field of quality control. He may be assisted by a small personal staff.

The plant chief inspector stands between sales, production, and engineering in disputes concerning quality production. He and his immediate subordinates accordingly should have some engineering training and extensive practical manufacturing experience. The farther one goes down the inspection division's chain of command, the less is any special engineering or mechanical training required for operative inspection. Mechanical skill and knowledge has been transferred to the inspection instrument in many cases. The work of inspection has been completely automatized in some mass production plants. The final inspectors, in plants making capital equipment to customer specifications, are often highly skilled mechanics, on the other hand.

The inspection division renders a technical service of facilitation. Yet it performs the function of comparison in determining the degree of quality produced in parts and products. Comparison is a phase of control.

Inspection cannot be placed under the production control division, however. To do so would be to violate our concepts of functional similarity. The importance and prestige of the inspection function would be reduced, if it were placed in a secondary staff position, to a point where it might not be able to function effectively. This would inhibit the proper development of a vital service. A certain quality is a requirement for the accomplishment of a primary service objective.

The Basis for Quality Control

The chief problems in the control of quality have to do with: (1) the selection of the attributes which each unit of product must have, within the practical limits of economical manufacturing, (2) the selection of quality standards, (3) the development of methods and instruments for determining and controlling the degree of quality produced, (4) a procedure for checking the accuracy of these instruments, and (5) an organization for quality control.

The attributes of the product and its quality standards therefore must be selected with a view to meeting satisfactorily the quality demands of the public. Their selection requires suggestions and opinions from a number of executives whose interest in manufacturing varies to some extent. The sales executive is closely in touch with the consuming public. He is best able to advise regarding changing quality demands. It may be necessary to discount his advice in part because the sales division naturally wants maximum quality at minimum prices to facilitate distribution. This may not be necessary to meet competition or possible except at a loss. The engineering executive can advise regarding the attributes necessary for the successful functioning of the product. His natural desire for mechanical perfection may cause him to insist on unnecessarily high quality standards. The production executive wants standards of quality that will make it easier to keep output high and costs low. He may tend to insist on standards that are too low. The inspection executive and the industrial engineer can advise on the practicability of the suggested quality standards in relation to economical standards of production. The materials executive can probably advise on the relation of available materials to quality maintenance. To harmonize these views, it may be desirable to create some committee, such as a product committee.

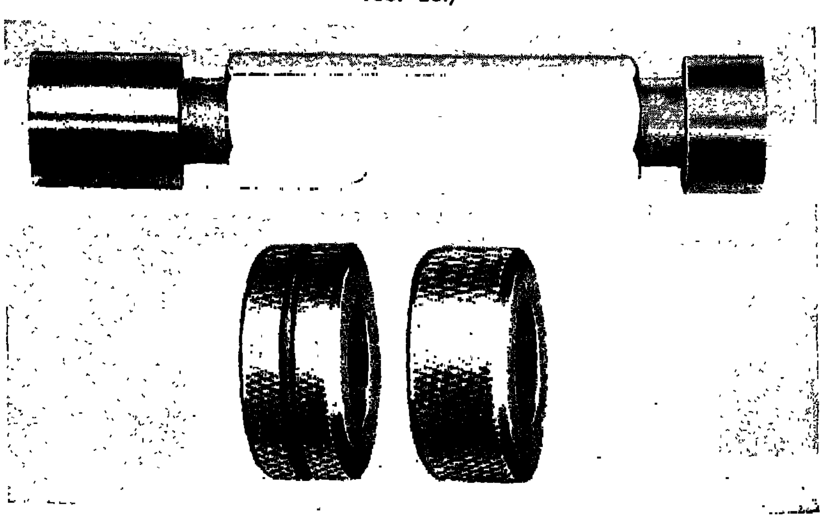
The final selection of attributes may include dimension, finish, color, strength, etc. Since they must be selected not only for the final form of the product but also for each stage in its production, the nature of

the manufacturing processes involved must also be considered.

Standards are a basis of comparison. They may be based on custom or convenience or be developed from some fundamental law. The standards of volume, weight, length, etc., in the Bureau of Standards at Washington are as accurate as is humanly possible, and the measures in daily use have been compared with them, directly or indirectly. The industrial organization must have standards with which each of the various attributes of the product can be compared at each stage of production. These standards should be expressed in units that are universal, at least as far as the particular industry is concerned. They should be easily read and understood by the average employee.

If the control of quality is to be effective, there must be practical means of comparison. These will vary with every industry. These means are crude in some cases and highly refined in others. Plug and ring gauges like those shown in Fig. 18.4 may be used in the interchangeable manufacture of metal parts. These gauges are simple to apply. They permit direct, quick measurement of the attribute of dimension. A tool-and-gauge inspector, who is stationed in our tool-making department, is checking the diameter of a hole in a jig, in Fig. 18.5 using an indicator gauge. This is a general-purpose instrument that permits the measurement of dimension within 0.001 inch or less. Other instruments that are capable of much greater accuracy will be seen when the problem of quality-control instruments is discussed.

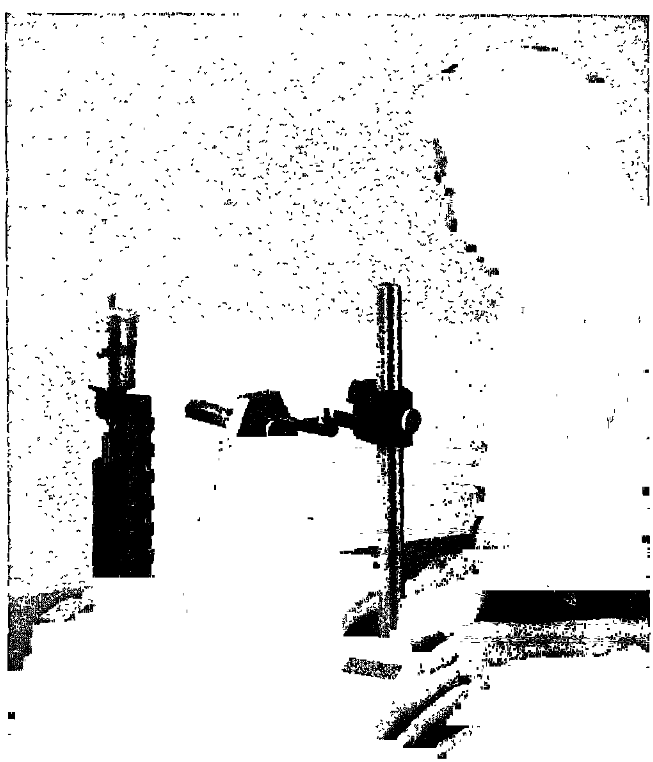
Fig. 18.4. Examples of Plug and Ring Gauges. (Courtesy, The Standard Tool Co.)



Principal Types and Phases of Inspection

Inspection as a function of comparison is found in other divisions of the organization. The checkers in the drafting room are responsible for the inspection of tracings. The maintenance department is usually responsible for the inspection of plant, machinery, and equipment. The personnel department performs an inspection function in connection with the selection and training of employees, plant sanitation, etc. The inspection department is chiefly responsible for the routine mechanical inspection of certain factors and results that affect primary operative performance, in so far as they condition the quality of the product directly. In general, this is true whether we are discussing an assembly industry or a chemical or mechanical process industry. The preceding discussion shows the principal phases of inspection to be: (1) receiving inspection, (2) tool and gauge inspection, (3) process inspection, and (4) product inspection. The inspection department may requisition

Fig. 18.5. Gauging Jig Bushing Holes. (Courtesy, Brown & Sharpe Mfg. Co.)



the assistance of the research laboratories when laboratory tests are required. Some concerns make some use of commercial testing laboratories.

Factors Affecting Inspection

The degree of quality required, the amount and kind of inspection that is necessary, and the nature of the processes are interacting factors which affect the work of inspection. In some cases the higher the degree of quality required, the greater is the care and precision necessary in inspecting the work. Each inspector is responsible for a smaller quantity of work, and the inspection division accordingly must be larger. More skilled and consequently higher-paid inspectors may have to be employed.

The character of the product affects the amount of inspection required. Some products are rough and crude. Such products need little inspection of work in process or the finished product. Others must be processed very exactly. These will be inspected more closely than the former. A machine composed of many parts may be required to do certain work with a high degree of accuracy. Those parts which affect its functioning must be machined to certain exact dimensions within specified limits of deviation. The final assembly of the machine must be inspected to insure that it will produce the required results.

The varying characteristics and requirements of operations create differences in problems of quality. On some operations it may not be necessary to inspect every component part. Sampling methods may be adequate. A casual inspection of the finish may be all that is required. It may be necessary in some cases, on the other hand, to inspect each part produced on a particular operation, using extremely accurate, sensitive quality-control instruments. It may be necessary, for example, when subsequent operations depend on the accuracy with which a given operation is performed. It may be necessary, also, when the proper functioning of other component parts of the mechanism depends on a highly accurate machining of each finished component. Operations differ, furthermore, in respect to the ease with which the quality of their output can be controlled. When the permissible deviations from the exact dimensions of the component are very small, a little wear on the tools, gauges, or the devices for holding the work may greatly increase the amount of nonstandard work. These holding devices are sometimes complicated; and unless the operative keeps them free from chips and other foreign matter, the work may not be seated in the device properly for correct machining.

The inspection instruments are important factors in the work of inspection. Their development represents a considerable transfer of skill and knowledge to the instrument, in some cases. This enables us to inspect more work accurately with less expensive inspectors.

The training and indoctrination of line operatives also is a factor in inspection. It is obvious that a well-trained operative will produce less scrap than one who is poorly trained. This is largely the responsibility of our line supervisors. It affects the work of the inspectors, nevertheless. Many concerns try to inculcate in their employees an understanding of the importance of quality, to themselves as well as to the customer. They try to make the organization quality-minded. It results in greater interest in quality, and more faithful observance of procedures and instructions for producing quality work.[6]

Attribute and Variable Inspection

There are two general kinds of inspection, representing chiefly degrees of refinement in quality measurement. They are attribute inspection and variable inspection.

Attribute inspection merely determines whether a particular quality characteristic is present in the product within acceptable limits of variation from the quality standard. The product is rejected if it is not. The inspector usually records the number of acceptable and unacceptable pieces in the lot or sample. He indicates the causes of the quality variance if he can determine them. The tapered plug gauge shown in Fig. 18.1 is an example of an instrument for attribute inspection. The hole in the part will either be acceptable as to taper, and the large diameter will register between the go and no go lines, or it will not.

Variable inspection measures the extent of quality variance from the standard. This variance is expressed in terms of whatever units of measurement are appropriate for the particular quality characteristic. If the characteristic is linear dimension, the units may be thousandths, ten-thousandths, or one-hundred-thousandths of an inch. It is obvious that we must have an instrument that will measure and indicate the degree of variance accurately, within permissible limits of instrument error. A tapered cylindrical surface is being checked, in Fig. 18.6, using a reed gauge and a sine-bar attachment. These variances are recorded for each lot or sample of the material under inspection. They may be posted to a

[6] Reference has been made previously to a booklet entitled *Oldsmobile Quality Control Program*. The foreword states that: "This booklet was developed for use as a text in a training program for Oldsmobile Inspection and Production personnel in the interest of maintaining and improving product quality."

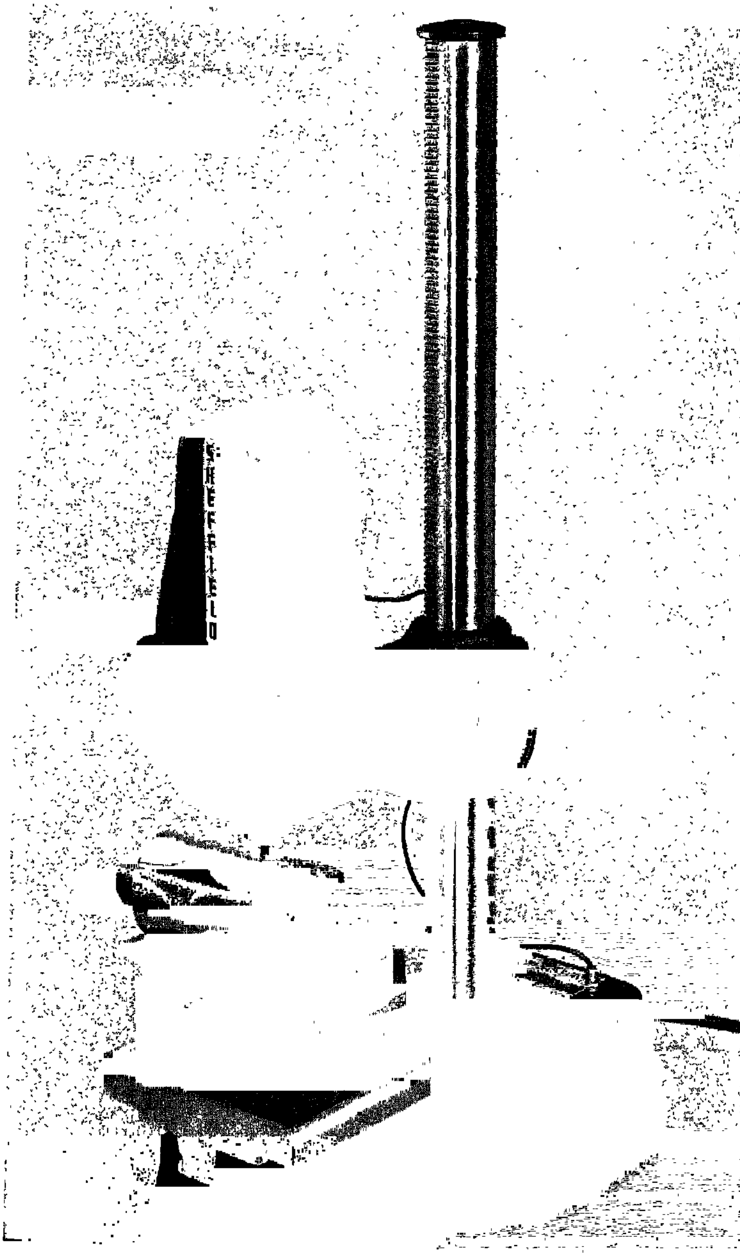


Fig. 18.6. Gauging a Cylindrical Surface, Using a Reed Gauge and a Sine-Bar Attachment. (Courtesy, The Sheffield Corp.)

chart to show graphically any trends away from the quality standard. This will be seen shortly when we take a brief look at statistical quality control.

Variable inspection usually requires more expensive instruments. Its operating cost may be greater than attribute inspection. This may be quite justifiable when it results in a substantial improvement in the level of quality. Variable inspection may, in fact, cause savings that offset any increase in the operating costs of inspection. It is the staff responsibility of our quality control executives to recommend either attribute or variable inspection for specific operations on particular parts. Variable inspection will probably be used when (1) the product is in a state of rapid technological development, (2) production methods are changing substantially, (3) new models are being introduced, (4) the organization is expanding and there is a considerable operative training problem, (5) quality levels are being raised, (6) a high degree of accuracy in producing the particular quality attribute is required, or (7) any other conditions are present that create an unstable quality situation.

Tolerances

Three kinds of standards—theoretical, engineering, and manufacturing—are usually recognized in metalworking industries. The theoretical standard represents the ultimate development of the product for which the engineering department is striving. It may be impractical at the moment, except under laboratory conditions, because of the absence of production methods or excessively high cost. Competition may preclude it because the public has not yet been educated to demand such a highly developed product. But this standard may have some practical value in so far as it guides the engineering department in developing the product. The engineering standard is the exact standard that will give the best performance at the present stage of the product's development. In the case of the size and shape of a given part, this standard is represented by the exact dimensions for the part that appear on the engineering drawing. This standard cannot be attained continuously. The manufacturing standard is the standard that can be maintained continuously and economically in production. It is the engineering standard modified by the permissible deviation from it. The magnitude of these deviations depends on the nature of the work. Thus in some highly accurate interchangeable metal parts, the permitted deviations in dimension may be as small as ± 0.00025 inch.

In the manufacturing of interchangeable metal parts, a terminology has

been developed for indicating the extent and size of deviation from the engineering standards of dimension. Thus the allowance is the minimum clearance space which is intended between mating parts. It represents the condition of the tightest permissible fit of the largest internal member mated with the smallest external member.[7] In Fig. 18.7, the allowance for the mating parts is 0.001 inch. The tolerance is the amount of variation permitted in the size of a part.[8] The tolerances for the two parts in Fig. 18.7 are both 0.001 inch. The limits are the extreme permissible dimensions of a part.[9] The limits of the diameter of the shaft in the figure are 1.250 inch and 1.249 inch.

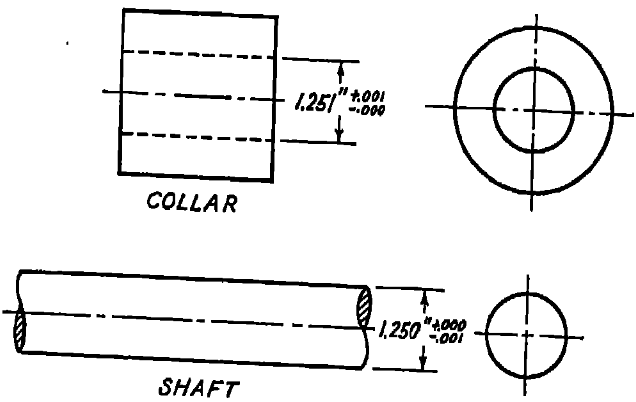


Fig. 18.7. Tolerances for Mating Parts

The concept of tolerance has been discussed in terms that are common in metalworking concerns. The same general concept is applicable to quality production in every industry. The terminology and methodology must be adjusted to fit the needs of the particular industry, of course.

Inspection Instruments

A quality attribute in a part or product cannot be produced continuously and exactly, to a specified quality standard. Some deviations from this standard are inevitable. The problem of quality control is largely to hold these deviations within tolerances, as indicated above. There may still be some proportion of defective product in a batch or lot of work, even with good manufacturing practice and good quality control.

[7] American Engineering Standards Committee, *Tolerance, Allowances, and Gauges for Metal Fits.*
[8] *Ibid.*
[9] *Ibid.*

The reasons for this will be seen shortly. Quality control depends on some form of measurement of quality attributes. It follows that the effectiveness of quality control can be no greater than that of the inspection instruments for quality measurement.

These instruments are not necessarily expensive and complicated, however. It has been noted previously that plug gauges are simple devices, and relatively inexpensive. There are some general requirements, nevertheless, that inspection instruments should meet. The more important ones may be summarized briefly as follows. (1) The instrument should be capable of measuring the degree in which the particular attribute exists in the product, and in units that are at least as small as those in which quality deviations must be recorded for control purposes. It is inadequate, for example, if it can register deviations only in units of 0.001 inch, when they must be controlled within ten-thousandths of an inch. (2) The limits of accuracy of the instrument must not impare the validity of the recorded measurements. The author recalls a case, during World War II, in which the tolerances for the diameter of the pistons of a fuel injection pump were ±1/20,000,000 inch. There was an instrument available on the market that could measure dimension in millionths of an inch. The probable error of the instrument was ±1/25,000 inch, however. Some experimental engineering was required to develop an instrument with an acceptable error. (3) If possible, the instrument should be sufficiently simple to permit the average employee, with training, to use it successfully. An automobile crankshaft that is out of balance when it rotates has a certain throw. This condition puts an additional strain on the crankshaft bearings, and in other ways lessens the efficiency and life of the motor. The balance of a stationary piece is not necessarily the same as it is when the piece is rotating rapidly. Machines have been developed that will test accurately the dynamic balance of a shaft. When a finished piece comes to a certain inspection station on the crankshaft line, an operative places it in a balancing machine that rotates the piece rapidly. If a line of light falls either to the right or the left of a center line on the gauge of the machine, the operator removes the crankshaft and takes off a little metal wherever he thinks it is necessary to balance the piece. He uses a heavy, coarse grinding wheel to do this. When the line of light falls on the center line of the gauge, the operator knows that the shaft is in proper balance. This man probably knows nothing of the theory of dynamic balance. The knowledge and skill of the scientist and the engineer have been transferred to the machine. A new type of operative skill has been created, however. The trained operative will balance the shaft

quickly, with not more than one or two grinds. Anyone else would grind it in two pieces, probably, before he got it in balance. (4) The inspection instrument should be sufficiently rugged to permit it to stand up in use without rapid loss of accuracy; otherwise the cost of instrument inspection, repairs, and replacements may be too high,

Inspection instruments may be classified as to function and use. In metalworking concerns, for example, three classes of gauges are often recognized: (1) master gauges, (2) inspection gauges, and (3) working gauges. The master gauge is "one whose gauging dimensions represent as exactly as possible the physical dimensions of the component. It is the gauge to which all other gauges and all dimensions of manufactured material are finally checked or compared."[10] Inspection gauges are those used by inspectors in determining whether the work is within the permissible limits of deviation. Working gauges are those used by the foremen, machine adjusters, and in some cases the workmen, to check the work as it is produced. After a certain amount of use, inspection and working gauges become inaccurate because of wear; as noted previously, they should be taken periodically to the quality standards laboratory for checking. A few good and bad pieces of work may be checked against the master gauges occasionally; this gives a check on the accuracy of the inspectors.

Many quality measurements are objective and quantitative; some of them may be qualitative and subjective, however. Medical doctors, for example, are not the only people who use stethoscopes. An inspector is shown in Fig. 18.8, applying a stethoscope to the heart of a truck—its motor. He can tell by listening to its operation whether it is running properly. If it is not, he may be able to make the adjustments that will correct its operation. He may reject the motor if he is unable to do so. It is largely a qualitative judgment on his part, in either case. The inspector must have judgment, skill, and experience when qualitative determinations are required. We cannot transfer skill and judgment to a stethoscope in the above case.

The preceding discussion has been chiefly in terms of the attribute of linear dimension. The problem of measuring nonlinear dimension may be equally important and more difficult. Not many years ago, a mechanic used a file to determine the hardness of metal after heat treatment; today unskilled girls can do this more accurately and quickly with a sceleroscope or some other hardness-testing device. Wherever possible, scientific discoveries are applied promptly to quality control. The photoelectric cell,

[10] *Ibid.*

Fig. 18.8. Checking the Operation of a Motor, Using a Stethoscope. (Courtesy, The International Harvester Co.)

a device whose electrical resistance is very sensitive to changes in the color or intensity of light, is now in quite common use. In one interesting case it has been used in the inspection of white beans. The beans are carried swiftly on a narrow-belt conveyor before the cell. When withered brown beans pass in front of the cell, an electric circuit is actuated, and another device brushes the subquality beans from the belt. To pick them out by hand would of course be far more expensive. X-ray machines are being used to detect flaws in castings, and so on. It is necessary to measure the level of sound that is produced by the operation of some devices. A noisy room air conditioner in one's bedroom window, for example, might dehumidify and lower the temperature of the air satisfactorily. It is doubtful, nevertheless, that it would contribute greatly to a good night's sleep. The inspector in Fig. 18.9 is measuring, in a soundproof room, the level of sound that is being produced by a room conditioner. He is recording the results of his test in terms of the unit of sound, the decibel. The inspector will reject the piece if the amount of

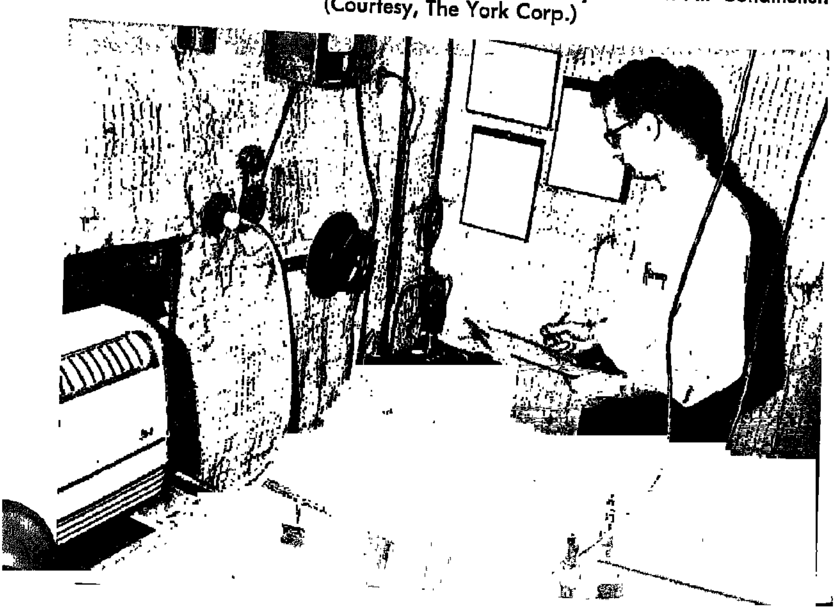
sound produced is above the permissible limit, as established by our research and product engineers.

The General Conditions of Inspection

There are certain general conditions, or problems, of inspection that should be noted. These problems have to do with the location of inspection operations, the stage or stages in the manufacture of the product where inspection should be made, and how much inspection is necessary.

There are two possible locations of the work of inspection; at some central point, or at the point where quality is produced, the bench or machine. The first condition is known as central inspection, and the second as floor inspection. The term "central inspection" does not imply that there is only one such point for the shop, or even for a department. It indicates merely a point at which certain inspection work is centralized. Central inspection has certain advantages. It clearly separates inspection from production, and may contribute to the control of production as a result. When fully developed, all worked material in process or in transport is stored at the central inspection point. This makes it possible to maintain a clean, orderly shop. All the work completed in a department should pass through some central inspection point, before leaving the department preferably, to establish the accountability of the department head for the production of quality work. It may be necessary, of course, to check the quality of work after certain specified operations within the department. This may not be done at a central inspection crib, however.

Fig. 18.9. Checking the Levels of Sound Produced by a Room Air Conditioner. (Courtesy, The York Corp.)



If the work is conveyed in standard, self-counting tote boxes, the number of boxes stored in the inspection crib gives an approximate idea of the load of work ahead of the department. Central inspection is not developed completely in most plants for several reasons. It may mean greatly increased movement of work in the department or plant, for one reason. In many cases the equipment in the shop must be rearranged before central inspection can be introduced economically. On the other hand, it may be possible to use less skill and cheaper inspectors, with central inspection, without lowering the accuracy and reliability of the inspection service. The work of inspection is under the immediate supervision of a highly skilled and experienced inspection foreman. It is claimed also that the cost of making an annual physical inventory of work in process is reduced, and its accuracy is increased, by the application of the central inspection principle.

Floor inspection has to do with the inspection of the work at the machine. It may involve the close, accurate inspection of each piece produced on a given operation, or only a casual sampling of the work. This inspection may supplement central inspection for work that cannot be brought economically into the central inspection crib. Inasmuch as the floor inspectors work independently to a large extent and have greater personal responsibility, they may be paid more than the crib inspectors.

The cost of inspection is a factor in determining when to inspect. One purpose of inspection is to avoid further expenditures of time and money on work that is already substandard. If the cost of inspecting a piece on a given operation may be greater than the cost of performing a subsequent operation, on the other hand, it is obviously more economical to withhold inspection until the later operation. Work going from one organization to another should be counted, and some evidence of the transfer of responsibility should be originated. All work whose quality is important is usually inspected at this time.

Where to inspect a piece is determined not only by the difficulty of producing the required degree of quality on a given operation, but also by the effect of this quality on the production of other quality attributes in subsequent operations. In machining metal surfaces, for example, the piece may be held in the proper relation to the tool by a holding device such as a jig or a fixture. It rests snugly in this device against certain holding points. The surfaces of the piece that rest on these points are usually known as reference surfaces because the tool forms a new surface in relation to them during the operation. As far as possible, subsequent operations also are done with reference to these surfaces. The difficulty of maintaining accurate relationships between dimensions and surfaces

is increased when a change to new reference surfaces is made. If the holding device is made accurately and is properly set up in relation to the tool, the correct surface must be formed on the piece, provided its reference surfaces have been made accurately. If they are not accurate, all operations made with reference to them will be inaccurate. Those operations that form reference surfaces are usually checked carefully, for these reasons.

The closeness of control and the amount of inspection that is required are governed largely by the same considerations that govern the use of variable inspection. These considerations affect the number of inspectors who must be employed. This number may vary from 10 to 30 percent of the primary operative employees in some plants. This is an important overhead expense factor in such cases. We can apply the principles of automation to the work of inspection in some instances, and thereby reduce the number of inspectors who are required.

Sampling Inspection

The proportion of a quantity of work that should be inspected may range from zero, through samples of various sizes, to 100 percent inspection. The latter means obviously every piece in the total quantity or lot of work. Sampling inspection limits the 100 percent comparison of a quality attribute to a predetermined proportion of the quantity produced. This proportion, or sample, is determined to be representative of the total quantity, or universe of data, by means of certain statistical techniques that are based on the theory of probability. The sample should be selected at random to assure that it will be representative. The larger the sample, the more likely it is to be representative, of course. There is always a risk that the entire quantity of material will contain some defective items, even though the sample passes inspection. A sample is never exactly representative. The problem is to determine the smallest sample that will reduce the risk within acceptable limits. The sample can be smaller, obviously, if the production processes are under control, and there is little tendency for quality to deviate from standard.

The principal objectives of sampling inspection are: (1) A reduction of the amount of inspection work, the number of inspectors required, and in consequence, the cost of inspection; (2) An improvement in the accuracy of the inspector's work. One hundred percent inspection of the entire quantity produced is not necessarily more accurate than sampling inspection. The latter may actually be more accurate. One hundred per-

cent manual inspection of thousands of pieces can be quite monotonous. The inspector may become inattentive and careless in doing his job. There is less danger of this when he is checking a variety of samples in the course of the day; (3) A reduction of the time required for inspection operations. Such operations are usually listed on the operation layout sheet for a part or product. It is evident that the lead time that is required for the manufacture of the product is reduced as the time required for inspection operations is decreased; (4) A minimum loss of material from the lot of material or product as a result of the application of the particular inspection method. Some inspection methods involve the use of tests that destroy the material which is tested. Coal, for example, when used in large quantities, is usually bought on specifications. The minimum acceptable heating value, in terms of BTU's per pound of coal, may be specified. The specification may state, also, the maximum amount of ash, the permissible sulfur content, or any other attributes that may be significant with respect to the intended use of the coal. The heating value of the coal may be determined in the testing laboratory by means of a calorimeter test. The coal is burned in the course of the test and the sample is destroyed. A 100 percent inspection of the heating value of a car of coal, would end with no coal, obviously. These is no choice, in this case, except to use a sampling technique.

A type of sampling inspection known as acceptance sampling should be noted. It is concerned with the acceptance or rejection of an entire quantity or lot of work. The conditions of its use therefore are essentially those governing the use of attribute inspection. The tapered plug gauge shown in Fig. 18.1 is a device for acceptance sampling. The number of defective pieces found in a sample is the basis for accepting or rejecting the entire lot. Standard sampling tables are available for the determination of the size of the sample and the number of defective pieces that will result in rejection.[11] This number is based on the maximum allowable percent defective. What is permissible depends on the calculated sampling risk that is acceptable. Acceptance sampling can be used to control the quality of the product at any stage in its production where attribute inspection is most applicable. It is used commonly in connection with receiving inspection or final inspection. Its objectives are those of any sampling inspection technique. It is concerned particularly with: (1) The

[11] H. F. Dodge and H. G. Romig, *Sampling Inspection Tables*, John Wiley & Sons, Inc., 1944. These tables are a well-known example. They have been widely used in connection with the application of statistical quality control techniques.

determination of the quality and acceptability of incoming purchased materials and parts; (2) The prevention of further expenditures of time, money, and effort on work in process that is already unacceptable. This is also an objective of variable inspection; (3) The determination of the quality and acceptability of finished products before shipment to the customer.

The preceding discussion of sampling inspection has developed the outline of the general method of approach. It may be summarized as follows:

1. The selection of a sampling method that will produce accurate, representative results
2. The determination of a representative sample size
3. The selection of a representative sample by random choice. This will be affected by a decision to use a single, double, or other sampling method
4. 100 percent inspection of the sample for the particular quality attribute
5. The recording of inspection results for quality control purposes
6. 100 percent inspection of a rejected lot to salvage the good pieces. This is not practicable unless their value is greater than the cost of inspecting the lot
7. Rework of rejected pieces, when practicable, to bring them within tolerances

Statistical Quality Control

Much has been written since World War II concerning statistical quality control.[12] SQC, as its proponents frequently refer to it, may be defined as a statistical technique, based on an application of the theory of probability, that facilitates the control of quality deviations. It employs the results of sampling inspection. Much that has been said about sampling inspection previously therefore applies to statistical quality control. It is the function of such control to maintain and present a record of quality production for an operation or end item that will show clearly any tendencies of quality to deviate from standard. These tendencies are usually shown on some form of quality control chart. It is also the function of SQC to present information concerning these deviations in a form that will facilitate corrective action. The methods of statistical quality control are applicable either to problems of attribute inspection or to variable inspection. It appears to be applied more widely in connection with the latter.

[12] The techniques of statistical quality control were developed during the late 20's and early 30's, apparently at the Bell Telephone Laboratories. The pioneer book in this field was written by W. A. Shewhart, a member of the technical staff. It is *Economic Control of Quality of Manufactured Products*, D. Van Nostrand Co., 1931. (There is often considerable time lag between development of a technique and its general acceptance by management.)

It will be discussed chiefly in connection with variable inspection for this reason.

The objectives of statistical quality control are basically those of quality control and sampling inspection. There are certain additional values with which SQC is usually credited in whole or in part. These are: (1) a prompt indication of the trend of quality deviations in the production of an operation or part, (2) prompt information that will indicate where corrective action should be taken, (3) a more accurate determination of the level of quality that is being produced, (4) greater interest among operative employees and minor supervision in quality maintenance, (5) a larger and more rapid reduction of scrap and rework than is likely when inspection is not given statistical support, (6) a more reliable determination of consumer's risk and producer's risk for use in purchasing and selling, (7) information that will facilitate an administrative control of quality production.

The requirements for an effective application of statistical quality control flow from the criteria for proper accomplishment of the above objectives. The effectiveness of a technique that is based on the theory of probability depends considerably on the stability of large numbers. It follows that there must be sufficient volume of production for the particular operation or item to justify the application of a statistical technique. There should be also a considerable standardization of product and process. SQC may have limited application, in other words, when we are making a single item completely to the customer's specifications. The variability of quality, furthermore, should justify the application of statistical techniques. Some question concerning the necessity for SQC may arise, certainly, when the quality of production on an operation has been stabilized at a level that is well within tolerances. The operations whose quality are to be controlled with the help of SQC should be determined. It is not necessary usually to apply quality control to each successive operation in the manufacture of a part or assembly. The cost of man-hours and machine-hours for subsequent operations may be less than the cost of inspecting the particular operation. The quality produced on subsequent operations may not depend on the quality of work on the particular operation.

The use of sound sampling and other statistical techniques is necessary, for reasons that have been discussed previously. The planning and development of such techniques is usually the staff responsibility of the statistical quality control section in Fig. 18.2. The selection of measuring instruments of accurate, reliable quality is obviously important. Accurate

statistical processing of inaccurate quality data can hardly produce an accurate quality evaluation. The quality control section may participate in the selection of quality control instruments, but it does not usually have the staff responsibility for a decision. The right of final decision should rest, of course, with the executives who are responsible for their correct, effective use. These are the executives who form the principal chain of command of the inspection division. These executives are the chief inspector, the inspection superintendents, and the inspection foremen, in Fig.18.2. The decision of the chief inspector should be made with the advice of his staff. It will be necessary probably to coördinate this decision with the industrial engineering or manufacturing methods division in some cases. This division may design and make some of the company's inspection devices. Some may be bought from outside instrument manufacturers.

A procedure is necessary that will assure prompt, timely quality comparisons. A warning of an adverse quality trend should be given by these comparisons in time to take corrective action before the tolerances for an operation have been exceeded. The effectiveness of any quality control method depends on the interest and support of primary operative executives and employees. This involves education concerning the nature and significance of quality. It involves also the communication of information concerning quality results to the people who are producing it. Some plants hang quality control charts at the operation that is being controlled, for this reason. These charts are posted periodically to give a current picture of the particular quality situation. The quality results of production are often summarized by primary departments, when we have developed a common denominator of quality. This ties in with an administrative control of quality that will be discussed shortly. The final requirement is common to any major activity of a competent organization that is well led: no activity is likely to be better than the organization that conducts it, and no organization is likely to be better than its leadership.

The statistical methods employed by SQC can be quite complicated. The methods used by the small plant are comparatively simple, for a number of reasons. The plant cannot afford the overhead expense of a large staff for statistical quality control. Highly refined methods for a satisfactory statistical control of quality may not be needed. The chief inspector may be unable to get the acceptance of the manufacturing line organization for anything more than a simple approach to the problem. The following discussion has been simplified for an additional reason:

The line executive needs only an administrative rather than a technical staff understanding of inspection problems. It will be assumed that some application of statistical quality control has been found to be practicable, and that this application has been accepted by the plant executive committee and approved by the plant manager. The general method of approach probably will break down into the following phases. It will be seen that some of them are a part of the general problem of quality control, rather than SQC.

A. *Planning for SQC*
   1. The determination of the operations whose quality should be controlled
   2. The determination of the type of inspection, either attribute or variable, that should be used to control the particular operation
   3. The determination of the sampling methods that should be used
   4. The selection of appropriate quality control instruments
   5. The design of statistical quality control procedure
      a. Determination of the statistical limits for quality control
      b. The design of quality control charts
   6. Organizational planning for statistical quality control
B. *Organizing for SQC*
   1. Education and training for SQC
   2. Installation of the plan for statistical quality control
C. *Controlling through SQC*
   1. Operative control of quality
      a. Reporting of inspection results for a particular sample of a lot or order of parts or product
      b. The posting of results to quality control charts
      c. The evaluation of whatever trends or conditions may be shown by the chart
      d. Reporting to the proper line authority any trends or conditions that may require corrective action[13]
   2. Administrative control of quality
      a. The evaluation and comparison of quality results by primary operative departments

Most of the problems of planning for statistical quality control have been discussed sufficiently for the purposes of this book. Some problems in the design of SQC procedure have not. It is important, for example, to determine the statistical limits in the variation of quality beyond which corrective action may be necessary. This involves the use of a common technique for determining standard deviation. The term refers merely to a statistical measure of the dispersion of a body of data around its mean

[13] These are basically the same phases of the comparison function that were noted previously during the discussion of control in Chapter 5.

value. The measure is simply the square root of the sum of the squares of the deviations, from the mean value, of the individual items in the universe of data. This idea can be expressed algebraically, as follows:

$$\text{S.D.} = \sqrt{(S)d^2/N}$$

where S.D. is the standard deviation; (S) represents the mathematical symbol "sigma," which means nothing more or less than "the sum of"; d^2 is the sum of the squares of the deviations; and N is the number of individual items in the sample. This concept is important in quality control for the following reason. Statisticians have shown that (0.6745 × S.D.) will include approximately 50 percent of the items in a body of data, provided that the sample is adequate and the sampling methods are sound; 1 deviation will include approximately 68.3% of the items; 2 deviations, 95.1%; and 3 deviations, 99.7%, approximately. It is obvious that a quality deviation, for an item on a given operation, that exceeded 3 standard deviations would be abnormal. It is regarded as questionable, usually, when it varies more than 2 deviations. A simple example, based on the tolerances for the shaft that is shown in Fig. 18.7 will show how this concept is applied in the determination of statistical quality control limits: The operation is "Finish grind the outside diameter of the shaft to dimension." The finished dimension is shown on the blueprint for the shaft that has been received from the engineering department. It is 1.250 in. + 0.000, − 0.001 in. This shaft is a standard part that is interchangeable in a number of models of our product. The usage of the part is large. Long runs on this operation are necessary to supply the requirements of our assembly and parts-and-service departments. The accuracy with which this dimension is produced in the shaft is an important factor in the performance of the completed product. The causes of a substantial number of customer complaints were traced, some time ago, to this part and to this grinding operation. The limiting factor in the problem was found to be the man, rather than the machine. The particular grinding equipment that is used on this operation is capable of holding a finished dimension within a tolerance of 0.0002 inch or less. This is greater accuracy than is needed for the particular operation. The chief inspector recommended that statistical quality control be applied to the operation. The grinding department foreman concurred. The quality of this item was brought under control as a result of further on-the-job training by a supervisor, under the general direction of the foreman. It was a result, also, of greater operator interest in the job. A lot of these parts have been received from the heat-treating department, and have been finished on the grinding

operation in question. The results are typical of the present condition of quality. These results will serve to illustrate how the quality limits were determined originally. The data is from an inspector's report showing the results of variable inspection of a sample;

1. Operation; finish grind
2. Sample No. 125; 25 pieces of part 1280, shaft
3. Ave. measured diameter of shafts inspected; 1.2495 inches
4. The sum of the individual deviations from the average squared; 0.0064 inches
5. S.D.$=\sqrt{64/25}$, or $\sqrt{2.56}$
   $=\pm 1.6$ ten-thousandths inch
   $=\pm 0.00016$ in.
6. The policy that has been recommended by the statistical control department of the chief inspectors division is that the control limits shall be set at 2 times the standard deviation. (This should include approximately 95.4% of the items produced, when we have taken enough samples to stabilize the results of the computations of limits.)
7. The quality limits;
   a. The maximum desired deviation $=2\times\pm 0.00016$, or ± 0.00032
   b. The control limits are therefore 1.2495 ± 0.00032
   c. The range limits are accordingly 1.24918 in. to 1.24982 in.

The original computations were continued on successive samples until they had stabilized themselves and the operation had been brought under control. It is not unusual to find certain operations on which rejections by the inspectors may be 30 percent or more of the total quantity produced, when we are starting into quantity production of a new model of product. The computed quality limits will be outside the tolerances for the operation, in such case. The production line organization, with the assistance of the manufacturing methods and quality control staffs, will be working hard on this quality problem until it is brought under control. Money is being lost on the operation. There is the danger also that defective parts will get through into the finished product. This danger has passed, apparently, in the above case. The average measured diameter of the shafts in the sample is exactly halfway between the limits established by the tolerances for the part. Three times the standard deviation from the average is within the tolerance limits. The operation appears now to be under control.

Quality control charts are of two general kinds, conforming to the basic kinds of inspection: charts for variables and charts for attributes. The principal charts for variables are $\overline{X}$ and $\overline{R}$ charts.[14] The $\overline{X}$ charts are those on which the average variable measurements of the particular

[14] The sign $\overline{X}$ is used by statisticians to represent the arithmetic mean.

quality attribute are plotted against successive sample numbers. The $\bar{X}$ charts are really plotted against time, since the samples ar usually taken at periodic intervals during the day. The $\bar{R}$ charts are those on which the range of measurements for the corresponding samples are plotted against the sample number. Both charts are usually shown on the same chart paper for a given operation and attribute. The principle attribute chart is the $\bar{P}$ chart. The percent defective products in a sample are plotted against the sample number on this chart. Control limits for the allowable variation in the percent defective between samples are established.[15] The trend of quality measurements against control limits indicates the need for corrective action.

The use of such charts for quality control purposes can be illustrated by the $\bar{X}$ chart for the finish grinding operation on the shaft, that was discussed above. This chart is shown in Fig. 18.10. The dotted lines show the control limits. The solid lines show the tolerance limits. The

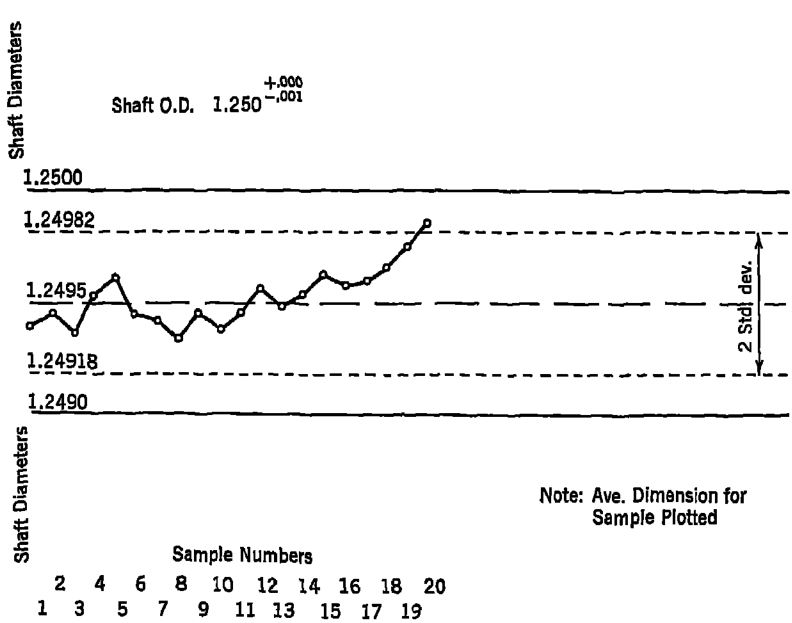


Fig. 18.10. An $\bar{X}$ Chart for Quality Control

[15] Specialists in the field of statistical quality control have developed formulas for determining these limits. They are based on the standard statistical formula for determining the probable error of a sample. See C. W. Kennedy, *Quality Control Methods*, Prentice-Hall, Inc., 1948, p. 103, and W. B. Rice, *Control Charts in Factory Management*, John Wiley & Sons, Inc., 1947, p. 69.

average outside dimension for each successive sample of shaft has been plotted as shown. It is evident that the trend in dimensional size has been toward the upper control limit since sample 8. It broke above this limit with sample 20. It is probable that the department foreman or supervisor had checked the cause of this trend before this happened, and had initiated corrective action. A range chart for this operation probably would show that the number of rejects on this operation has been increasing, even though the sample average is still within the tolerance limit. This is less serious, in this case, than it would have been had the trend been toward the lower control limit. Shafts that are oversize can be reworked. They would be scrap if the shafts were ground below size.

Quality control charts are frequently posted at the place of the operations that are to be controlled. These charts may be posted, as samples are inspected periodically, by supervisory personnel or by the inspectors. The purpose of the charts is to help line operative personnel to do a better job of meeting its quality responsibilities. This practice of posting the charts at the bench or the machine has a further advantage: the operative employee can see the score. He too can note an adverse quality trend before he has started to produce scrap or rework. The chart, when backed by quality education of the organization, arouses interest in quality maintenance, and contributes further to a quality-minded organization.

The problems of organizing for and controlling through statistical quality control are no different basically than for any other function of operative management. The rank and file of the organization should be educated concerning the purposes and practices of SQC. This is usually necessary to gain understanding, acceptance, and support for it. No plan is likely to be successful without the support of the people who must operate it. It is necessary to develop the statistical control procedures and train people in their use. The proper working and inspectors' gauges must be supplied. The system is usually installed gradually, to the extent that is warranted, beginning with those departments where the quality of work is most likely to be improved by statistical quality control. The use of the charts for quality control purposes has been discussed sufficiently for our purposes.

Purchasing, Sales, and Statistical Quality Control

Items that are mass-produced in volume are frequently checked for quality by sampling inspection. There is a probable and reasonable range of error in sampling. It is obviously desirable to get a meeting of minds

between buyer or vendee and seller or vendor concerning the maximum percent defective product in a shipment that will be acceptable.[10] This maximum percent defective should be specified in the purchase contract, when quality is an important purchase consideration. It is evident that the contract should specify also the quality standards, sampling methods, and inspection instruments that are to be used by the vendor in the final inspection of the product and by the vendee in his receiving inspection. The quality control organization should be coördinated by the purchasing department, or by the sales department, for this reason, when clauses concerning quality standards are being inserted in purchase contracts. Statistical quality control experts have developed certain terms that describe the sampling risks that are involved. *Producer's risk* may be defined as the chance taken by the vendor that some lots shipped will contain more than the maximum allowable percent defective product, despite his sampling inspection, and will be rejected by the vendee's receiving inspection department. *Consumer's risk* may be defined as the chance taken by the customer, or vendee, that his receiving department may accept more than the maximum allowable percent defective product, despite the sampling inspection of purchased materiel by his receiving department. These risks can be controlled by proper sampling methods.

Statistical Quality Control of Office Production

Many of the developments that have been taking place in primary line operations have also been taking place in staff operations. Office production has been mechanized in an increasing degree. Production control methods for office work have been developed. Other innovations have been introduced for the purpose of improving the quality of office work and reducing its cost. Office work has to do largely with the operative phases of staff functions. The cost of staff work is overhead expense. The application of SQC to office work is one of the interesting developments of recent years. Most of the applications appear to have been made to the more routine, repetitive phases of office service work, such as typing, in large concerns where it is performed in volume. The objectives, principles, and general methods of approach for applying SQC are the same for secondary or staff production as they are for primary or line produc-

[10] Statistical quality control specialists use the symbol p_2 to designate the maximum percent defective product that is acceptable. They use the symbol p_1 to designate the minimum percent defective that the vendee can expect to get. The symbol R_0 is known as the "operating ratio." It is the ratio p_1/p_2. It enters into the determination of the correct sample size N. The determination of such values are problems for the concern of the specialist, rather than the line executive.

tion. The conditions of application may be quite different, however. The General Electric Supply Company, for example, summarized 13 months' experience in applying SQC to office work as follows:

1. It increased worker interest in producing high-quality work.
2. The quality of work was raised.
3. Prompt discovery and investigation of errors permitted effective spot training.
4. The amount of inspection and checking, where done before on a 100 percent basis, was reduced to a 50 percent basis or less.
5. Employees, supervisors, and management got a better knowledge of the real quality of work output.
6. The quantity of work output increased, along with quality.[17]

The above company reduced the amount of inspection in the calculating section of its Newark, N. J., office after 13 months from a 100 percent basis to a 40 percent basis. Quality increased in this section from 99.3 percent to 99.7 percent.

The office manager has the staff responsibility for a leadership of ideas in the improvement of office economy and effectiveness, in concerns where he is a technical staff executive rather than a chief clerk. It follows that he is the one who should guide the application of SQC to office production.

Administrative Control of Quality

Operative controls of performance, with respect to the quality of work done in completing specific projects, have been discussed previously. An administrative control evaluates group performance rather than project performance. It therefore evaluates the performance of the executive who is in charge of the group, since he is responsible for its work. A sharp improvement in results is obtained frequently, when we begin to measure the accountability of the responsible executive. An administrative control, in the phase of comparison, summarizes the project results that have been reported by operative controls. These results are summarized on the basis of the organizational groups that have produced them. The same thing can be done with the results of operative quality control. It may be difficult, however, to make interdepartmental or interdivisional comparisons of quality levels and quality trends. Each department, for example, could make different products by different processes, using different quality standards and tolerance limits. It is more likely, in such cases, that each department must compete against its own overall record of quality production, over a period of time.

[17] "Office Quality—New Ways to Improve it with Statistics," *Modern Industry*, March 15, 1953, p. 50.

PROBLEMS

1. A certain concern has been buying certain parts for one of its products from a well-known and reputable manufacturer. This vendor delivers them each week in accordance with a schedule given him by the purchasing department. The unit purchase cost of the part is very small. The quality of these parts has always conformed to specifications. They have been moved from the receiving department directly to the assembly department accordingly, to avoid the time and expense of inspection. Lately, however, some of the assemblers have complained that many pieces do not fit easily into assembly, thus preventing them from making their usual piece-rate earnings. The department foreman also has complained that production is being held up because of too many substandard parts.
   (a) What may be the limiting factors in this problem? What corrective action would you suggest in this case?
   (b) What phases of control are involved?
   (c) What are the relationships between quality control and production control in a case of this kind.
2. Of the 5 operations required on Part 1130, Operation 1, is extremely important. The quality of the subsequent operations depends on it. Inspectors on this class of work are paid $1.25 per hour. Because production is intermittent, they may inspect a large number of orders in the course of a day. A check was made to determine the time and cost per piece for inspecting each operation on this part. Cost figures were obtained from the cost department; and except for the inspection time, which was estimated, inspection figures were taken from inspection reports. The results were as follows:

	Operation				
	1	2	3	4	5
Rejections	0.8%	0.2%	0.6%	1.2%	0.6%
Inspection time, per piece	4.0 min	0.5 min	3.5 min	5.2 min	1.7 min
Cumulative material and labor cost after each operation	$1.50	$1.84	$3.10	$3.45	$3.65

   The standard lot for this part is 50 pieces, and each part is given a final inspection before being sent to stores or assembly.
   (a) What operations would it be economical to inspect completely and in detail? Have we enough information to answer this question accurately? What additional facts do you need?
   (b) Is inspection cost the only consideration in determining the amount that will be spent for inspection?
3. The quality control department wishes to set up statistical control limits for inspection of a part which will be produced in large volume over a long period of time. The desired thickness of the part is 2.16 inches. When a sample lot was taken the measurements of the parts were as follows:

Number of Parts	Measurements in Inches
2	2.152
4	2.153
8	2.155
12	2.156
14	2.157
15	2.158
18	2.159
20	2.160
17	2.161
15	2.162
14	2.163
12	2.164
9	2.165
5	2.166
2	2.167

(a) Would such measurements indicate that statistical quality control would be possible?

(b) The department wishes to set up a control chart using 2 standard deviations as the outer limits for this part. Draw such a chart and calculate the upper and lower limits of acceptability of the part.

(c) The tolerances for the part that have been set by the engineering department are approximately the equivalent of 3 deviations. What are these tolerances, approximately?

4. When the volume of 5-lb packages of sugar produced by a manufacturer reached 20,000 per day, management believed it desirable to mechanize the entire packaging and sealing operation. One problem was that of filling containers with the exact net weight, since more than that amount would add to production costs, while a lesser amount was not only illegal, but also resulted in complaints from retailers and customers. Containers were filled by gravity flow while on an automatic conveyor, passing under a hopper containing the sugar. The problem of short weight was considered to be more important than the problem of excess weight. This problem was solved by placing a "floating" section of the conveyor line directly under the sugar hopper. This section was connected electrically with a weighing mechanism. When the quantity of sugar in the container reached the minimum weight limit of 5 pounds, the mechanism shut off the feed mechanism automatically, and moved the filled container to subsequent sealing and packaging operations. The mechanism was quite sensitive and fast. The excess weight of sugar, above the 5-lb minimum was held to very narrow weight limits accordingly.

(a) What are the possible advantages of such automatic inspection devices with respect to costs, quality competition, and capital turnover?

(b) What principles of quality control were involved in the above case?

CHAPTER 19 •

• Inventory Control and the Materials Supply Function

The Supply Function and Its Objectives

FROM the manufacturer's standpoint, production consists of the proper application of men and machines to materials for the manufacture of goods. In addition to the materials from which the product is made, there may be literally thousands of items that are necessary for the conduct of the business. Materials inventories require a large investment. This investment may represent a large proportion of working capital. In consequence, the problem of supply is one of the most important problems of management. The supply function may be defined as the work of providing the requisite materials in the proper quantities at the proper time and place, and at the lowest cost consistent with the specified quality. It therefore has to do with the procurement, maintenance, and disbursement of inventories in a manner that will serve the company's various operations economically and effectively.

Poor performance of supply functions may result in serious losses in any plant. Because of delays in purchase and delivery, materials may not be on hand at the plant when needed for production. Such interferences with production are costly. Stocks of materials or supplies may become exhausted; rush shipments of them mean higher costs. Inventories may be overexpanded because of unduly large purchases or too many separate items carried in stores. Dollar ratios of inventories to sales quickly become abnormal when business declines. Many of the failures during every depression result directly from excess inventories. Other losses may be caused by variations in the quality of the materials purchased and received by the plant. Such variations may adversely affect the cost of production and customer satisfaction with the product. Failure to salvage

waste and scrap materials from the various processes may mean a considerable leakage of profits into the scrap pile. Companies which do not have a good materials control system usually close their books only annually or semiannually because of the difficulty of taking a physical inventory of raw, worked, and finished materials. The consequent lack of current information concerning the company's condition may impair the effectiveness of managerial control. There are many opportunities for waste in the handling, storage, and movement of materials. The success of the company may be greatly affected by the quality of its materials management methods in these and many other ways.

Many concerns install expensive accounting and cost systems and watch expenditures carefully. Safes or vaults are provided for the cash on hand. An accounting for it must be made to the last penny. On the other hand, stocks of materials, costing large sums, are left with a minimum of protection, and control of these inventories may be very poor. It is not unusual for large concerns to have inventories which represent an investment of millions of dollars. In some industries, the materials cost constitutes 60 or 70 percent of the total cost of production. Cash on hand seems more important and real to some people, nevertheless, than far greater amounts that are invested in materials.

A materials procurement and supply division of a company is a staff organization. Its objectives, like those of any other staff organization, are secondary. These objectives are chiefly values that our line organizations need to accomplish the company's primary objectives, salable values for the customer. The division contributes directly to the accomplishment of a highly important collateral objective of the business organization, a profit. This is, of course, the principal objective of the businessman. The supply division is secondary only in order of service to the customer. It is a primary staff department in most manufacturing concerns. This status is determined largely by the nature and importance of its objectives. The following are some of the more important: (a) adequate quantities of the right kinds of materials and supplies, when and where they are needed, (b) materials whose qualities suit them to their intended purposes, (c) minimum materials purchase, storage, and transportation costs, (d) minimum loss from deterioration, obsolescence, or theft of materials, (e) maximum turnover of inventories in transit and in stores, (f) a minimum of interference with operations, due to supply failures, and other values that will be noted later. It is evident that some of these values must be contributed in coöperation with other agencies within the organization.

The Organization of the Supply Function

All functions, both managerial and operative, reside originally in the line organization. The staff phases of these functions are differentiated from the line progressively, as a business grows and becomes more complex. There are a number of factors that may govern such differentiation. These factors include the size of the business, the characteristics of the product, the type of manufacturing, the nature of the particular staff work, the boss's ideas concerning how the function should be organized, and others. There can not be a one best way of organizing a staff function for all manufacturing companies. There may be such a way for any one company. It may be helpful, accordingly, to break down a function into its principal phases. The decision as to which subphases shall be assigned to staff, and in what manner and degree, must be left to the management of the particular company. It must make the decision in the light of the requirements of its particular situation. The principal phases of the supply function appear to be the following: (1) procurement, (2) traffic and transportation, (3) storage, (4) materials handling, (5) salvage, (6) inventory control, and (7) materials standardization. The staff organization for supply in Fig. 19.1 is based on these phases. It is intended merely to provide a basis for a discussion, later, of each department within the plant supply division. It operates at the plant level under the general direction of a plant procurement and supply manager. This executive may also be called the general purchasing agent in some plants.

By procurement is meant the work of securing the materials and supplies for production and the conduct of the business. This may be done by manufacture or by purchase. It is the business of the plant to manufacture and sell a finished product. Inventories of the finished product and the parts of which it is composed are normally procured by manufacture. In some instances, certain materials and supplies may also be produced in the plant. The average plant, however, purchases most of its raw materials and supplies, and probably certain parts that it cannot produce to advantage. The purchasing department has the staff responsibility for procurement by purchase. The department is concerned with the study of materials, markets, and vendors. It coöperates with other departments in determining whether to make or buy certain parts, in cost reduction, and in other activities that require joint line and staff action. The department performs other functions, under the direction of the purchasing agent, that will be discussed later.

The transportation of goods or materials usually becomes necessary

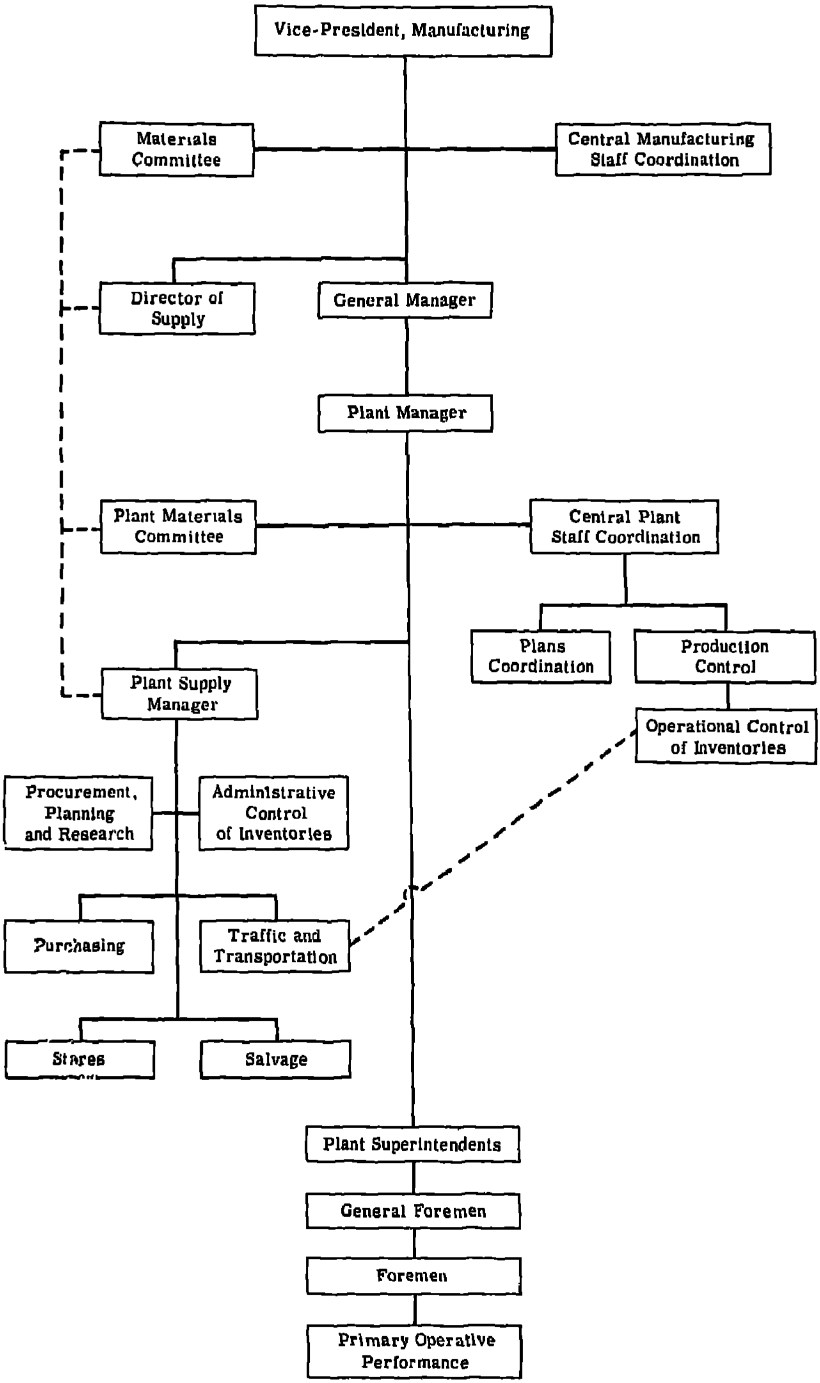


Fig. 19.1. A Staff Organization for Procurement and Supply

when title to them or responsbility for them is transferred. There are accordingly two principal phases of this work; the internal transportation of materials, and the transportation of materials or finished product into or out of the plant. The first has to do with the movement of materials within the plant. It may be under the general storeskeeper. External transportation has to do with the movement of materials from a vendor to the company, or with the movement of finished product to the customer. The traffic department is under the purchasing agent in many plants, because of the greater volume of incoming materials. It is organized as an independent department within the supply division in Fig. 19.1. This assumes that the volume and cost of transportation are sufficient to warrant it. The department operates in such case under the direction of a traffic manager.

The stores department is responsible for the proper storing and piling of materials, the selection of materials handling equipment, the handling and control of stock, the organization and location of storerooms, etc. The general storekeeper, or stores superintendent, accordingly, is responsible for the operation of our plant warehouses and storerooms. The receiving, internal transportation, and shipping functions may also be placed under his general direction. These functions complement the storing functions. These involve the handling and movement of materials. These functions and storing are functionally similar in other respects. The receiving section must work closely with receiving inspection. The latter is usually under the chief inspector. The salvage function involves the handling, processing, and disposing of waste and scrap materials. It is shown in Fig. 19.1 as an independent department. Salvage is sometimes regarded as a phase of the stores function.

The work of planning, organizing, and controlling the supply function requires the use of standards, as does any other phase of management. Much of the work of developing these standards may be done by other technical staff departments, such as engineering. Materials standards affect the work of sales, accounting, finance, and production, as well as engineering and supply. The plant materials committee, in Fig. 19.1, has been set up to coördinate the needs and ideas of the organizations that are affected by materials standards. It may coördinate also the thinking of those line and staff groups that are concerned with procurement and supply plans. Its membership usually includes representatives from the departments affected. The manager of materials and supply may be the committee chairman.

The procurement planning and research section is concerned with

studies and plans development in the area of procurement and supply. It serves immediately the needs of the supply divison. Its recommendations must have the concurrence of the department heads, within the division whose work is affected, and the approval of the plant supply manager. The plans are his when he accepts them. It may be necessary for him to get the concurrence of the plant materials committee and the approval of higher line authority, before putting his plans into effect. The section chief is shown, in Fig. 19.1, as reporting directly to the plant procurement and supply manager. This represents a current trend, because of the increasing importance of the procurement planning and research function. It may be found under purchasing in some companies, however. Much of the sections work has to do with procurement by purchase. It will be discussed in connection with purchasing for this reason.

Inventory control is the function of constraining, regulating, and coördinating the procurement and disbursement of materials, in accordance with our inventory and manufacturing plans. The objectives of inventory control will be discussed shortly. A distinction should be made for organizational purposes, between an administrative control and an operative control of inventories. An administrative control has to do chiefly with coördinating the execution of procurement programs, with respect to classes of materials that must be supplied and to the organizations that use them. Staff responsibility for such administrative control should be assigned to the supply division. Operative control of inventories has to do with coördinating the provision of certain materials, as requisitioned, with the needs of the line departments for these materials for specific orders or schedules. This operative control should therefore be assigned to production control. Both administrative and operative inventory control should be coördinated with one another, and with accounting.

A director of procurement supply, who reports to the vice-president in charge of manufacturing, is shown in Fig. 19.1. He develops and recommends company procurement and supply policies. The director's office develops interplant procedures for inventory planning and control. This office surveys interplant requirements for like materials. It may integrate company purchasing power by originating corporate contracts for such materials. Such contracts should receive the concurrence of the materials committee, as well as the approval of higher line authority. His office may also initiate the development of standards and specifications for materials that have company-wide use. The director of supply and his staff act as consultants to the supply managers of the various plants, when requested.

He performs in the supply field the other characteristic duties of a headquarters staff executive.

Inventory Planning

An inventory plan is the basis for effective, economical procurement and supply. Such a plan states how much of each class of materials should be carried in our inventory during a coming period. It states probably what should be the beginning and ending inventories for the period, and the rate of inventory turnover that should be achieved. It will indicate changes in inventory policy, if there are any. At the plant level, the plan will indicate the requirements for individual items of parts, materials, and supplies that are carried regularly in stores. Any plan sets up the basis for effective action leading to the economical achievement of assigned objectives. It is important obviously. A brilliant execution of a poor plan can produce only mediocre results at best. Inventory planning is merely the function of formulating an inventory plan. The plan may be worked out initially by the procurement planning and research section, in Fig. 19.1. Execution of the plan would be coördinated by inventory control.

There are a number of possible objectives of inventory planning and control. A maximum inventory turnover rate, and a minimum absorption of working capital are usually desirable. There must be adequate assurance, however, that there will be no interferences with operations due to supply failures. Management may wish to protect its materials costs against inflation. It may anticipate inventory needs farther into the future, in such case, than it would if unit prices for materials did not have a strong upward trend. Protection of operations against supply failure may be the principal objective in some cases. There may be others.

Any business planning function has two major phases, administrative planning and operative planning. These phases exist even in a one-man organization. Administrative planning of inventories has to do with the determination of procurement programs, probable rates of use, inventory levels, and turnover rates for classes of materials and major organizational groups within a company. The director of supply, in the company shown in Fig. 19.1, probably will have staff responsibility for inventory planning at the corporate level, under the general direction of the vice-president of manufacturing. It is likely that he must coördinate his plans with the company's comptroller. The final coördination of thinking may be accomplished by the materials committee. The plant manager also has administrative as well as operative responsibilities for plant inventories. He has a plant supply manager to handle the staff phases of this problem.

The methods of inventory planning vary with the size of the company, and the nature and size of the various inventories. It is possible to indicate only some of the general considerations that affect administrative planning procedure. These considerations will be discussed in connection with the supply manager's functions, under the plant manager. These considerations have to do usually with (1) the maintenance of a prescribed or standard inventory turnover rate, (2) conformity with a prescribed purchase and inventory policy, and (3) the use of sales-inventory ratios. Central plant staff control may break down an approved production program to get a corresponding program of materials requirements. This should include finished parts and product that are manufactured to stock, as well as prime materials and purchased parts. It is assumed, to simplify the problem, that the inventory of a minor stock item of product is being planned. The following information is available concerning the forecast sales of the item and the criteria of an inventory level that will be satisfactory to the plant manager.

S, forecast sales—\$120,000 per year of Product A, or \$10,000 per month.
T, standard turnover rate for this class of product—6 turns per year, or 0.5 turn per month.
I_b, estimated inventory at the beginning of the coming month—\$8000. This is the same, obviously, as the inventory at the end of the current month.
L, procurement policy—we shall assume that it is a 90-day coverage in this case.
R, the desired sales-inventory ratio—we shall assume that in this case it is 5.5 times per year, or 0.458 times per month.[1]
P, the amount of the particular item that must be purchased or produced to meet the requirements of the problem—we are producing in this case.

The quantity that should be produced to maintain a certain turnover rate can be determined by the following relationship:

$$P = S\left(1+\frac{2}{T}\right) - 2I_b = \$10{,}000\ \left(1+\frac{2}{0.5}\right) - (2\times\$8000)$$
$$= \$34{,}000 \text{ worth of the item, at the unit sales price, to be produced}$$
$$I_e = P + I_b - S, \text{ or } \$34{,}000 + \$8000 - \$10{,}000 \text{ in this case}$$
$$= \$32{,}000, \text{ ending inventory}$$
$$I_a = S/T, \text{ or } \frac{\$10{,}000}{0.5} \text{ in this case}$$
$$= \$20{,}000, \text{ average inventory for the coming month}$$

[1] This is the ratio for the electrical parts and supplies industry for 1952. See *Dun's Review* and *Modern Industry*, December, 1953. It is not an inventory-turnover ratio of course. It varies, furthermore, between industries, the condition of the particular industry, our position in the business cycle and other considerations. It follows that there is a ratio that is normal over a period of time, as well as one that reflects current conditions.

The simple use of a turnover ratio has a leverage effect on our inventories: The inventory at the end of the coming month tends to be too high if the inventory at the end of the current month is too low. It may be that the company should not end the coming month with a \$32,000 inventory of this item.

A policy for inventory planning and control is merely a rule for the guidance of supply executives. Such a policy is an aid in determining the extent to which the demand for or usage of the particular item should be covered by procurement. A 30-day coverage would be approximately our monthly requirement for the item. It is assumed that under present conditions of demand and supply the company is maintaining a 90-day coverage of the above product item. In this case;

$L = 90$ days, or 3 months coverage, approximately
$P = S \times L$, or \$10,000/mo$\times 3$
$= \$30{,}000$ worth of the item to be produced, provided the inventory is in balance
$I_e = \$28{,}000$ in such case

The ratio of net sales to inventory indicates the level of demand that can be supported by a given inventory. It indicates, if it is an industry figure, the level that is required to keep inventories competitive. On the basis of the ratio that has been given in the above data,

$$I_e = \frac{S}{R}, \text{ or } \frac{\$10{,}000}{0.458} \text{ in this case}$$
$= \$21{,}834$ worth of the item to be in stock at the end of the coming month
$$P = S + I_e - I_b$$
$$= \$10{,}000 + \$21{,}834 - \$8000$$
$$= \$23{,}834$$

The materials committee has recommended to the plant manager, after much heated discussion, that the company should manufacture \$24,000 worth of the product. The recommendation has been approved. This means that the company must produce 8000 units, because the net unit sales price is \$3.00. How about the parts and subassemblies that make up the product? This problem will be left to the production control department, after the operative and administrative controls of inventories have been tied together. The problem of materials and inventory standardization must be considered first, however.

The Importance of Materials Standardization

The closeness and accuracy of control are a function of the completeness and accuracy with which standards have been developed. Control

depends also on the effectiveness with which these standards are applied to the methods, factors, and conditions of performance. Reasonable economy and effectiveness in manufacturing are impossible without some control of the kind, size, and use of inventories. Without this control there is danger of excessive investment in inventories, low inventory turnover, loss from obsolescence and spoilage of materials, and excessive variations in inventory and operations. These cause fluctuations in employment, high unit material costs, and poor customer service because of inability to deliver promptly. High manufacturing costs are caused either by interferences with production resulting from supply failures or by the production of uneconomical quantities of finished parts or assemblies, etc. Adequate standards are as important for the management of materials as for any other phase of management.

Product Standardization

The principal objective of the businessman may be a profit, but the objectives of the business organization are customer values and service. The product conveys to the customer the utilities that enable him to satisfy his needs and desires.

It is evident that materials standardization has its genesis in the product. The product itself often creates inventory problems because parts, assemblies, or finished products are frequently manufactured or purchased for stock. In consequence, the problem within the concern tends to break down into two general phases: the simplification and standardization (1) of the product, and (2) of raw materials and supplies. In addition, there is frequently the problem of simplifying and standardizing products within the industry.

Standardization Within the Industry

Simplification may be defined as that policy of management which seeks to conduct all activities and functions of the enterprise in the least elaborate manner consistent with any given purpose. Inventory simplification in industry deals largely with the elimination of excess variety. Everyone desires some means for expressing and emphasizing his individuality. New models are introduced and changes are made in existing models to play on this desire of customers for distinctiveness. Many lines offer a great variety of styles, many of which represent the whims and fancies of the public rather than any real need. In some cases, 10 or 15 percent of the items in the complete line are responsible for 90 percent of the sales; this means that there is a light demand and probably a low

turnover for the remaining 85 or 90 percent of the items offered to the public. Simplification within an industry aims to eliminate as far as possible those items for which there is little need. This results in economies for the producer and better service for the public.

Simplification within an industry involves the coöperation of the principal producers in that industry. It may be realized generally that more types and styles of product are being offered to the public than are necessary, but competition may prevent any one producer from reducing his line. If a customer cannot purchase from his usual dealer a special style that he thinks he needs, he will get it from a competitor if possible, and probably give him also the rest of his order for standard items. Therefore there must be some agreement among the leading producers in the field before there can be any considerable curtailment of styles and models. Such agreements must not result in any diminution of competition, curtailment of reasonable customer service, price fixing, or other practices that may be of interest to the Department of Justice, or the Federal Trade Commission. Simplification is obviously in the public interest during a war emergency. Governmental sanction of a sound application of the concept is not a difficult problem, for this reason. An example of simplification during World War II was the development of national emergency, N.E., steel specifications.

Product Simplification in the Company

It is possible to simplify and standardize the line of products of a specific company even when there has been no simplification within the industry. Often this results in large savings to the company. Many machine elements have been standardized as a result of the work of the various engineering societies. In addition, other elements of the product can often be standardized between various models, styles, and sizes. For example, three sizes of the same type of machine may use shafts which are identical as far as their mechanical functions and characteristics are concerned, but which may differ somewhat in their dimensions. Although there might be some waste of material in the smaller sizes, it might be better from the standpoint of manufacturing economy to standardize on the large size. The shafts could then be manufactured in larger quantities. Most of the advantanges claimed for simplification and standardization in the industry will also follow the application of the same principles to the individual line of products in a concern.

There are some lines in which a certain amount of diversification is necessary. This is particularly true when the salability of the article is

largely dependent on style, or the industry supplies another one which demands great diversification. It may be possible to attain some degree of simplification, however, even when style is important. Thus the William Gilbert Clock Company reduced its line from 500 to 75 items. This concern's policy is to keep the number of models carried at any one time at a constant figure as far as posisble. The sales of the various models are constantly checked. When a given model begins to fall off, it is discontinued and a new one is substituted for it. The consumer still has a reasonable opportunity to satisfy his desire for distinctiveness, but at the same time, the company and the public benefit ultimately from the effects of standardization. Some concerns have a policy that they will withdraw a product line in which they can not develop some minimum competitive position. This position is usually some percentage of the industry sales of that line. Such a policy tends to result in simplification of their inventories, as well as their manufacturing operations.

Public and Consumer Reactions to Product Simplification and Standardization

People who are accustomed to using certain special goods will not give them up readily. They can usually be educated to accept such changes, because it is to their advantage to do so. The consumer gets a more abundant supply of a better product, with better service, at less cost. The automobile field, in which the public has come to recognize the advantages of a standard product, is an excellent example.

Some of the usual objections to standardization and simplification hold that it tends to automatize the worker, retard mechanical progress, destroy initiative, limit markets, interfere with the development of foreign trade, etc. In most cases, they are based on various misconceptions such as the notion that it is possible or desirable to standardize all the factors in industrial production, that standards are or should be permanent, etc.

The Standardization of Materials and Inventories

The intended uses of each kind of material in the concern's inventory should be determined. The combination of characteristic attributes that each kind should have to enable it to meet its intended uses also should be determined. The function of materials standardization deals with such problems. When properly performed, this function results in most of the economic advantages that have been noted previously. Its principal phases are: (1) inventory analysis, (2) the development of a standard classification of materials, (3) the simplification of inventories, (4) the develop-

ment of materials specifications, (5) the development of symbols for the inventory, and (6) the creation of an organization for the maintenance of inventory standards.

INVENTORY ANALYSIS

The first step obviously is to list all the items of direct or expense materials carried regularly in stores. This may not be so simple as it sounds. However, a list can usually be made on the basis of records of past physical inventories, analyses of purchase orders, and such inventory records as there may be. When completed, the list should be analyzed. Who uses a given material, and for what purposes? It may be used in several departments in the manufacture of widely differing products. What other materials resemble it? Different materials may be used in manufacturing different parts or products, although in many cases the specifications for these materials may be quite similar. What are the characteristic attributes of each material? How much of it is consumed per unit of time, and where is it consumed? This information must be available before any decision can be made on the feasibility of eliminating a given item, extending its use by specifying it for additional purposes, etc.

INVENTORY CLASSIFICATION

A classification of materials is necessary to facilitate analysis of the inventory, as well as for subsequent financial and operating control.[2] A general classification will include;

1. Raw or Direct Materials: Such materials enter into and are directly chargeable to the product.
2. Indirect Materials or Supplies: This classification includes such materials as belt lacings, lubricating oils, fuels, etc., that are necessary for but do not enter directly into production, and therefore cannot be charged directly against the product.
3. Worked Materials: This term usually refers to material to which men or machines have been applied, but which has not been completely processed into finished parts or products. It is sometimes economical to split an order, putting into stores a portion which has progressed beyond a certain operation. In such cases an item of worked materials should appear on the stores books.
4. Component Parts: These are parts that have been completely processed for assembly into the finished product. In many cases, they are manufactured to stock.
5. Finished Product: This term refers to products, except salvaged material,

[2] Stuart Heinritz, *Purchasing*, Prentice-Hall, Inc., 1951, p. 199 gives five basic requirements for inventory control. The classification of inventory items is listed first. This does not imply that it is necessarily the most important, of course.

which have been finished for sale. Under some conditions, finished products also may be manufactured to stock.

6. Salvage Stores: This includes all scrap and waste materials received by the salvage department, and all products reclaimed from salvage materials for sale or replacement in stores. In some cases, it may include manufactured by-products.
7. Unclassified Stores: This classification includes all materials not carried regularly in stores, or not classified elsewhere.

Although the general classification of materials will differ between concerns, this one should provide a tangible concept of the complexity of the supply problem. Any one of these groups may include hundreds of items representing an investment of thousands of dollars.

The existing classification may be used at first. It may have been developed, however, from a financial rather than an operating point of view. It may be desirable, therefore, to modify it or even to formulate a new one, subsequently. In so doing, an attempt is made to group items together on the basis of some fundamental similarity as to kind or use, and when possible to classify by responsibility for use, thus facilitating control. When this classification is finished, the principal classes of materials will probably become controlling accounts in the general ledger. The accounting department accordingly has a direct interest in this phase of the work.

Inventory Simplification

An important objective is reduction in the number of items carried regularly in stores. The classification and analysis of the inventory may bring to light opportunities for simplifying it. Thus when several different materials are used for the same or very similar purposes, an examination of their specifications may show that some of them are quite similar. This suggests the possibility of eliminating most of them from the inventory list, but tests may be necessary in determining which are best suited to the particular purose. Again, a certain item may be essential, but its usage may be so low and intermittent as to preclude economical purchase and storage. It may be better to eliminate it from the classified list and to substitute some other item for it, or to buy it in the required quantities when and as needed. Other possibilities for simplification may present themselves. When the inventory has thus been pared to a minimum, the result is the standard classified inventory list. Department heads cannot requisition materials not on this list without special authorization, and some concerns restrict each executive to a special list within it that fits his particular needs.

Materials Specifications

Each item in the classified list presumably represents the best material for the particular purpose. The determination of the characteristic attributes that it should have may have required considerable investigation and study. It is important that they be recorded in the form of specifications for use by the purchasing department in buying, the engineering department in designing, and any other organization units that may need them.

There are various sources of information outside of the company itself that are helpful in working up materials specifications. Many of the larger technical societies have standard specifications for important materials. Manufacturers' catalogues often contain technical information about the materials described therein. The United States government publishes a general schedule of supplies which contains specifications for the great variety of materials it purchases. It may be desirable, frequently, for the research laboratory to run tests or undertake reseach in determining the proper specifications for a material for a given purpose.

The form in which this information is arranged will vary necessarily with the material and its use. In general, the specification will contain such data as the name of the item, its materials symbol, a statement of the uses for which it is intended, a general description of it, and a detailed statement of its chemical and physical properties, the quality of its attributes, the method of inspection, any tests to be applied on receiving it, etc. The purchasing department cannot always get prompt delivery of the specified materials in the required quantities at a satisfactory price. The specification therefore may state what materials can be substituted on proper authority. The purchasing department usually has no authority of its own to substitute other materials for those specified on a requisition. When specifications have been set up, no change in them should be permitted unless approved by the materials standards committee. A given material may be suitable from the standpoint of design, but be expensive to process; it may be satisfactory from the standpoint of designing and processing, but the market for it may be chronically thin. With so many interests involved, changes should be permitted only by a central authority that is in a position to correlate them.

Inventory Symbols for Materials

Good records should facilitate the classification of the information that they collect. The clerical work of recording a large number of items,

divided and subdivided into many classifications, is greatly facilitated by the use of a logical system of symbols for these items. Accordingly almost every concern has applied the principles of symbolization to some extent in some phase of its operations. Some plants may have several systems which are used for various phases of management but which are not logically related to one another. To illustrate, the part called for by a production order may bear the symbol P101. The symbol by which the materials division identifies this part may be a simple number such as 1126; and the engineering department may have assigned still another number to it. The more information that the clerk has to record, the greater the chance of error and the clerical expense involved. It is obvious that three systems of symbols are undesirable if one can be devised which will serve all three purposes adequately.

A symbol is a concise representation of a name and a description. The materials division is chiefly interested in the symbols for materials, but any symbol system which is to be fully usable should be tied in with the accounting and production symbol systems. Therefore the symbols should represent names and descriptions of accounts as well as of materials. This is desirable because the results of any business are finally expressed in the general ledger accounts. Hence the items for which symbols are to be provided should be grouped on the basis of the classification of controlling accounts. It may be necessary to modify the classification in use, however.

Two general types of symbol systems have been used in industry, the numerical and the mnemonic. The mnemonic system may be more scientific, but the numerical system is by far the more common.

The Numerical System

In the numerical system, a series of numbers is applied to the items. The various classes of items are indicated by breaking the series into groups and subgroups. For instance, the numbers 1 to 999 inclusive may be reserved for one class of items, the numbers 1000 to 1999 for the next class, and so on. The disadvantage of such a system is that there is nothing in the symbol itself to identify the item, unless one can remember the arbitrary divisions of numbers that have been established. When several numerical systems are in use, a given number, say 1166, will probably designate a different item in each system; it may be an employee's clock number, an order number, a material number, and so on. While the numerical system has its disadvantages, it is easier to develop than a mnemonic system. It is easier to apply in connection with the operation of accounting and tabulating machines. Moreover, filing papers and

records numerically is usually faster than filing with a complicated alphabetical system.

The Mnemonic System

The word "mnemonic" means "aiding the memory." Hence a mnemonic symbol system is one in which the symbols are combinations of numbers and letters, so constructed as to suggest the identity of the items they represent.

Words have varying interpretations. Because of this, papers and communications that are hastily written under pressure of the day's work are always in danger of being misread. A paper which originates in the shop may be written crudely and smudged with grease and dirt, thus increasing even more the difficulty of deciphering it. Some products are composed of hundreds of parts whose manufacture requires thousands of operations and many materials, and a great number of various papers for managerial and operative purposes. Their handling and the control of production are greatly facilitated if these papers can be identified easily and quickly by their recipients. Much of the possibility of error is eliminated if the written description of an item is supplemented by a short, concise symbol that suggests its own meaning. Items should be classified and standardized before they are given symbols. Complete classifications of accounts, equipment, materials, products, and functions should be available before any attempt is made to develop a mnemonic symbol system.

In a mnemonic symbol system, each letter in a symbol indicates a function or a characteristic. The first letter, called the root letter because it denotes a general classification, indicates the subject of the symbol. For example, the letter S is used in almost all mnemonic classifications as the root letter of the general classification, stores accounts. The other letters in the symbol qualify the meaning of the root letter. Thus the symbol SS is generally used for steel stores, the root letter S indicating stores accounts, and the second S indicating that the particular classification is steel stores. A number preceding a letter in the symbol shows a modification of the characteristic or function which that letter represents. When there is a large number of items, to indicate each particular item by a mnemonic letter would expand the symbol to such lengths that it would be cumbersome; hence serial numbers preceding the last letter of the symbol may be used in such cases to indicate particular items. While this confines the length of the symbol to convenient limits, it is open to the objection that it reduces the mnemonic value of the symbol.

The base classification should conform to the general classification of accounts, which in turn should conform to the divisions of responsibility in the organization. The following example is taken in part from the base classification used by a large munitions manufacturer. Only enough is shown to illustrate the principle of its development.

Base Classification Sheet

Expense Accounts
- A (A)uxiliary expense accounts (chiefly technical staff services)
- B (B)usiness expense
- C (C)ommercial expense
- D (D)epartmental expense of line units, factory

Deferred Expense Accounts
- E
- F

Product Accounts
- G (G)uns and other firearms
- H
- J
- K (C)artridge products
- L
- M (M)iscellaneous products not classified elsewhere
- N
- P
- R

Stores Accounts
- S (S)tores

Product Accounts
- T
- U
- V Sal(V)age products
- W

Asset Accounts
- X Fi(X)tures, tools, jigs, gauges, and similar equipment
- Y Machiner(Y) and equipment
- Z Real estate, buildings, and building equipment

The letters in parentheses were selected as root letters, in most cases because of their mnemonic value. The A classification represents the expense accounts of the service departments; for example, the AP accounts might be used to control the operating expense of the power department. Business expense includes all the expenses of the general administrative organization. Commercial expense includes the various accounts of the sales organization. Departmental expense includes the expense accounts of

the directly productive factory departments. The classifications from G to W inclusive are product accounts, with the exception of S, which is reserved for stores. Those from X to Z inclusive are asset accounts.

The supply organization is particularly interested in the classified stores symbols. These do not include worked materials and finished product, although these items may be carried regularly in stores, and ledger sheets may be provided for them in the stores ledgers. Mnemonic symbols are used in the stores classification which follows. Such symbols facilitate the work of the stores clerks, as well as the ledger clerks. Numerical symbols are more common, as previously noted, because of the use of mechanical tabulating and posting equipment.

Classified Stores[8]

S-A Office supplies
B Brass and brass products, including pipe and fittings
C Coal, coke, and other fuels
D Wood and wood products
E Electrical supplies
F Fastenings, bolts, nuts, nails, screws, etc.
G Gaskets and packings
H Hangers, stands, boxes, bushings, pulleys, and clutches
J Gears made of all materials
K Chemicals and pigments
L Liquids, lubricants, oils, gasoline, and paints
M Machine and engine parts for boiler power and water supply
N Metals not otherwise classified, such as babbitt, lead, zinc, etc.
P Pipe, pipe fittings, and tubing made from cast iron, wrought iron, and steel
R Rubber scrap
S Steel, wrought or cast iron, and products made chiefly therefrom
T Tools, implements, and supplies
U Building materials such as cement, quartz, sand, and brick
V Abrasives, emery wheels, grindstones, etc.
W Wearing apparel
X Stores not otherwise classified
Y Fibrous and textile materials such as belts and sundries, hose, rope, and twine
Z Special parts and supplies for equipment

The Organization for the Maintenance of Inventory Standards

Inventory standards will not maintain themselves; like any others, they may deteriorate rapidly if no one is responsible for them. The supply division is a technical staff organization. It has staff responsibility for such

[8] Sanford E. Thompson and W. O. Lichtner, in L. P. Alford (ed.), *Management's Handbook*, Ronald Press Co., 1944, p. 470. (This has been regarded as a classic example of such a classification.)

inventory planning functions as may be delegated to it. Its decisions, accordingly, are subject to the approval of higher line authority and the concurrence of coördinate line or staff authorities whose work is affected. It is required to render certain services of facilitation in connection with the supply function. It would seem, therefore, that this division should be responsible ultimately for the development and maintenance of inventory standards. However, its personnel is not trained or equipped for certain phases of standards development. It will duplicate facilities present elsewhere in the concern, furthermore, if it tries to do the work. This work affects the interests of other units outside of the supply division. Any organization and procedure for the development and maintenance of inventory standards accordingly must provide for the use of investigational facilities that may be located elsewhere in the organization, and for the coördination of all interests affected within the organization.

A materials standards committee may be set up for these purposes as is shown in Fig. 19.1. It may be composed of representatives of the production, comptrollers, engineering, manufacturing methods, purchasing, and stores divisions. This committee determines the objectives, policies, and general methods of developing inventory standards. It has usually the right to call on the standards and research departments for any technical service that is required. The committee must pass on any standards that are developed. In most cases, it must approve requests for the inclusion of new items in the classified inventory. The standards committee passes on recommendations from stores or purchasing that certain items be dropped from this inventory and placed on the obsolete list. The supply division manager may be chairman of the committee.

The Economic Quantity to Manufacture or Purchase

In intermittent manufacturing, standard parts are often manufactured to stock. This creates certain inventory problems, among which is the question of what quantity of the particular part should be ordered, produced, and carried in stock. It may be very expensive to set up several machines for an order. The unit setup and preparation costs may be exorbitant, if only a few pieces are made. On the other hand, if a large quantity is produced, the unit interest and storage charges may be too high. There is greater danger of depreciation and obsolescence of the inventory. Furthermore, the turnover of work in process and worked materials inventories is a function of the quantities that are manufactured on an order. Turnover releases capital, thereby increasing the rate of profit

and reducing the interest charges on borrowed capital. If an order calls for a sufficiently large quantity, it may be possible to run it in several batches or lots. These considerations also affect the average quantity that must be carried in stock. Somewhere between these limits is the quantity that is most economical to manufacture.[4]

The general relations of production and consumption of a part that is manufactured to stock are shown in Fig. 19.2. The symbols in this figure have the following meanings.

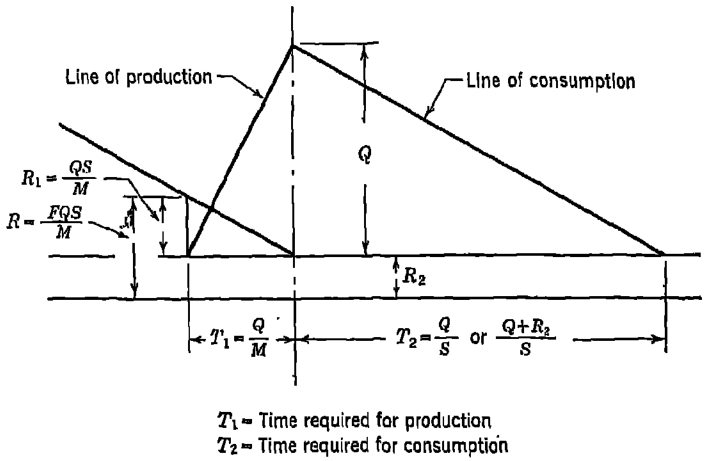


Fig. 19.2. Relations of Production and Consumption in Inventory Control with Intermittent Manufacturing

F = a stock factor. In batch production, the old supply can be exhausted before the new order is completely manufactured, and F becomes the batch factor; Its value will be approximately the ratio of the time for the completion of the first batch to the total manufacturing time, and of course will be less than 1. If the total quantity on the order must be manufactured as a single lot, then F becomes an excess stock factor, and its value must be greater than 1.

M = the rate at which the quantity is manufactured, expressed in pieces per year. It is likely to be the rate of production on the slowest operation on the part.

Q = the economic quantity to order, expressed in pieces.

R = the reorder point.

R_1 = the theoretical reorder point. If a new supply of the material is ordered when the quantity in stores reaches this point, the new supply should be received by the time the supply on hand is exhausted.

[4] This has been discussed previously in connection with production control for intermittent manufacturing.

R_2 = any excess stock above normal consumption requirements that is carried to meet such contingencies as delays in the delivery of the material.

S = the estimated rate of consumption for the part, expressed in pieces per year. The average rate of consumption shown by stock records may be used if conditions are not expected to change.

T_1 = the time required to produce the total quantity on the order. This should include setup, process, and float time, expressed in years.

T_2 = the time, in years, required to consume the quantity Q at the estimated rate of consumption.

The equation below was derived by this author. It governs with reasonable accuracy the relations between these factors and certain others that will be noted shortly, as they enter into the determination of the economic quantity to produce.[5] This equation may be regarded as a statement of the law of manufacturing economy in production for stock.

$$Q=\sqrt{\frac{2AMS}{(M+kS)(C'Z+2BE)}}$$

in which

A = The setup and other preparation costs of production.

B = A bulk factor, expressed in square feet of net storage space required per unit of the particular item.

C' = The standard unit of cost of the item, expressed in dollars.

E = The charge for the use of storage space, expressed in dollars per square foot of net storage space per year.

k = A batch production factor which is equal to $(2F-1)$.

Z = A turnover factor, expressed as a ratio, that represents roughly the mark-up on standard cost necessary to obtain a satisfactory profit.

The symbols Q, M, and S have the same meanings as in Fig. 19.2.

An example may aid in clarifying the significance of the above relationship. It is assumed that the particular part which must be reordered for stock is small, and that about 200 pieces can be stowed in a bin. This bin has a bottom area of approximately 1 square foot, and there are 8 tiers of bins in each bin stock. The standard charge against the stores department for net floor space is \$3.00 per square foot per year. (The term "net floor space" denotes the total storeroom floor area less the space required for aisles, office, and similar space not usable for storage purposes.) The part is usually manufactured at the rate of 50,000 pieces per year; the consumption for the coming period is estimated at the rate of 2000 pieces per year. The production of the part is usually broken up into

[5] A simpler, but less accurate, approximation of the economic ordering quantity is given by the following formula: $Q=\sqrt{2AS/C'Z}$. Both of these formulas, and one by Professor Paul Norton, have been processed by the Remington-Rand Division of the Sperry-Rand Corporation, for computation on its Type 409 Electronic Computer. See *Inventory and Production Control—Economical Lot Formulas, MC-837.*

lots; the first lot should be completed and delivered to stores by the time the total quantity is about half completed. The preparation cost of producing the order is approximately \$200.00. The standard cost of the part is \$2.50 per piece. Analysis has shown that Z should be 0.3, for this class of product. Therefore

$$A = \$200.00 \qquad E = \$3.00 \text{ per sq ft/yr}$$
$$C' = \$2.50 \text{ per piece} \qquad M = 50{,}000 \text{ pcs/yr}$$
$$Z = 0.3 \qquad S = 2000 \text{ pcs/yr}$$
$$F = 0.5$$
$$k = (2F-1) = 0.0$$

$$B = \frac{1}{200 \times 8},$$
$$= 0.000625 \text{ sq ft of floor space/pc}$$

$$Q = \sqrt{\frac{2AMS}{(M+kS)(C'Z+2BE)}}$$
$$= \sqrt{\frac{2 \times 200 \times 50{,}000 \times 2000}{50{,}000\,[(2.50 \times 0.3) + (2 \times 0.000625 \times 3.00)]}}$$
$$= 1030 \text{ pieces, the most economical quantity to order}$$

No production executive, regardless of his experience, can solve a problem involving so many factors solely on the basis of qualitative judgment with any assurance of reasonable accuracy. On the other hand, it would be impracticable to solve this formula by longhand methods whenever a production order for stock parts had to be orginated. Where such relationships have been applied, special slide rules or computing charts have been developed to make the work relatively quick and easy. Electronic computers have been used in recent years. Even so, the time of expensive office machines should not be spent unnecessarily. It should not be necessary to compute economical ordering quantities more frequently than semiannually or annually. The ordering quantity for a given item can be adjusted by the ratio of current requirements to those for which the quantity was originally computed. This is not an accurate adjustment. The curve of unit materials costs varies with procurement quantities, in the form of a broad-based U. The curve is skewed usually in the direction of increasing quantities. The error of a proportional adjustment is therefore not likely to have a substantial effect on unit material costs. Economical ordering quantities should be recomputed periodically, however.

The above problem is characteristic only of certain conditions of intermittent manufacturing. It is found in a great many concerns, however. Some large durable goods manufacturers produce directly to a parts production program, under conditions of continuous manufacturing. They produce continuously the quantity required to satisfy customer demand.

The concept of a limited economical ordering quantity is not applicable, obviously. When manufacturing is completely intermittent, and production is directly to the customer's specifications, there is little or no problem of the economical quantity to order. In general, such a concern makes only the quantities required to meet the customer's order.

Relationships such as the above are often helpful. It should be recognized, nevertheless, that there is no mathematical substitute for executive judgment. For example, business conditions are changing constantly; have they changed since the concern determined its requirements? No formula can answer such a question.

Our discussion has been confined to the manufacture of stock parts, but a similar problem arises in connection with the purchase of supplies, raw materials, and parts from outside sources. Here also there is a preparation cost of purchasing. A considerable length of time may elapse before the purchasing process is completed. For this reason, relationships similar to the above formula have been developed for purchased materials.[6]

The economic ordering quantities may be regarded as a form of inventory standard. As such, this is of direct interest to the supply division. Their determination is sometimes one of its responsibilities, accordingly. An operative control of inventories involves coördinating supply with the line organization's requirements for production. The manufacture of parts for stock is a production problem. An operative control of inventories, from this point of view, is a coördinative staff problem. The determination of ordering quantities for individual parts has been assigned to the production control department, for this reason. The manager of procurement and supply should have an opportunity to participate in the determination of production requirements for stock parts. The standard procedure for determining ordering quantities should be approved by the materials standards committee. The interests of the supply division will be adequately protected by this procedure. The principle of compulsory staff advice should apply in this situation.

The Reorder Point

A problem that is closely related to that of ordering quantities is the determination of the point at which to place an order for new stock with the purchasing or production department. If it is placed too early, the inventory is run up unnecessarily; if it is not placed soon enough, there is the danger that the stock of the particular item may become exhausted and

[6] For a discussion of the problem, see an article by Ralph C. Davis in *Manufacturing Industries*, May 1927.

that operations will therefore be held up. Referring to Fig. 19.2, we see that in the case of manufactured materials,

$$R_1 = ST_1, \quad \text{and} \quad T_1 = Q/M$$
$$R = FR_1 = FST_1 = \frac{FQS}{M}$$

In the case of purchased materials, $R = FST_1$.

The Balance-of-Stores Section

A balance-of-stores, or stores records section usually maintains the operative controls of inventories of a plant under conditions of intermittent manufacturing. This section may be composed of a ledger unit, an order unit, and a unit for checking and extending requisitions. The ledger unit maintains records of material inventories, apportions direct materials against production orders, and posts the material requisitions and credits to the stores ledgers. It may price them and extend their values. When the available supply of a given item drops to the reorder point, the order unit initiates manufacturing or purchase requisitions for the procurement of a new supply. It follows through to make sure that the material arrives in stores before the supply on hand is exhausted. These and similar duties constitute the work of the balance-of-stores section. It should receive some evidence of every transaction that affects the value or disposition of the material inventories.

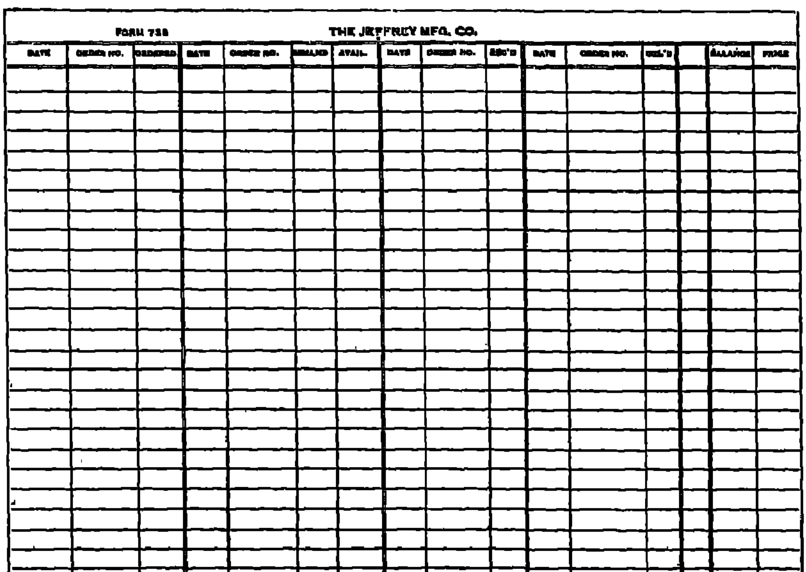
A good ledger control of direct materials assists the production division in controlling production. It reduces the number of production holdups resulting from lack of material. Such control coördinates the work of the stores department in filling requisitions with the need of the line organization for materials. It aids in holding inventories to a minimum. It tends to reduce interest charges and to keep down losses from inventory depreciation and deterioration. A good ledger control facilitates the checking of physical inventories. Because it affords a means of watching consumption figures, this control often makes possible the elimination of many low-consumption items and the consequent reduction of the number of items carried in stores. A good ledger control aids in coördinating inventory control and purchasing. It makes possible a closer coördination of materials, production, and cost control. Such control facilitates the monthly closing of the books of account. It is apparent that the stock ledgers supply information that is necessary for the coördination of the primary line function of production, with the work of supply and other staff functions. It will be regarded, therefore, as a phase of production control. The work of the stores ledger section must be coördinated with the

administrative control of inventories, under the plant supply manager in Fig. 19.1, and with cost accounting under the plant accountant.

The Stores Ledgers

Carl Barth, a disciple of Taylor, developed a stores ledger sheet early in the present century. Most of the better ledger sheets in use today are developments of it. Machine accounting equipment is used in some concerns to post and extend inventory control records. An inspection of machine-posted records will show, in most cases, that they too have basically the form of the ledger sheet that was developed originally by Barth.

Barth ledger sheets are filed by classes of materials and the number or symbol of each individual item. One of these sheets is shown in Fig. 19.3.



FORM 7[illegible] THE JEFFREY MFG. CO.

DATE	ORDER NO.	ORDERED	DATE	ORDER NO.	DEMAND	AVAIL.	DATE	ORDER NO.	REC'D	DATE	ORDER NO.	DEL'D		BALANCE	PRICE

Fig. 19.3. The Barth-Type Stores Ledger Sheet for Direct Materials. (Courtesy, The Jeffrey Mfg. Co.)

The Barth type of sheet has basically four columns: On-Order, On-Hand, Demand or Quantity Apportioned against production orders, and Quantity Available for apportionment to new production orders. The "Ordered" column is intended to coördinate purchasing or production with inventory control. The "On Hand" column furnishes a current record of the inventory of the particular item, from which its usage can be determined. The

"Apportioned" column shows the amount of direct material set aside for orders which have been planned but are *not yet in process; it* insure the availability of the material when it is needed. The "Available" column shows the amount of the item which is available for new orders.

When a purchase requistion for an item of direct materials is accepted by the purchasing department, the purchase order number, date, and quantity ordered are entered in both the "Ordered" and the "Available" columns. If the reorder point has been determined properly, the quantity ordered will be in stores before the present supply is exhausted, unless unusual conditions arise. It is available, consequently, for allocation against new orders. When the order is received, the quantity is deducted from the amount on order and added to the total quantity in the "On Hand" column. When a materials requisition, like that in Fig. 19.5, is apportioned for the requirements of a production order, the quantity required to fill it is added to the total quantity in the "Apportioned" column and at the same time deducted from the total in the "Available" column. While the quantity called for on the requisition has not yet been delivered from stores, it is no longer available for new orders. When the requisition is presented to the storeroom and the required material is delivered, the requisition is forwarded to the balance of stores section, where it is posted by the ledger clerk to the ledger sheet for the particular kind of material. The unit price of the material is entered on the requisition. The clerk deducts the quantity on the requisition from the totals in the "On Hand" and "Apportioned" columns. When he receives a requisition that has not been apportioned previously, he deducts the quantity issued from the totals in the "On Hand" and "Available" columns. The same general procedure is followed when reordering finished parts or end products that are manufactured to stock. The chief difference is that a manufacturing requisition is originated, rather than a purchase requisition. Because expense materials cannot usually be apportioned, ledgers for such items generally carry the "Ordered" and "On Hand" columns only; otherwise the procedure is much the same.

One characteristic of a good record is its provision for an internal audit of entries. The accuracy of the entries in the stores ledger can be checked easily at any time; the quantity on order plus the quantity on hand should always equal the quantity apportioned plus the quantity available.

Pricing Material Requisitions

In some plants, the stores ledgers are used only for quantity control; in such cases, there may be no direct connection between these ledgers and

the general books of the company. It is better practice to link up quantity control and value control in the stores ledgers, and to coördinate the inventory procedure with the general and cost accounting systems. To do this, the unit value of each item of material must appear on its stores ledger sheet.

The chief methods of pricing stores requisitions and credits are: (1) the average unit price, (2) "Fifo," (3) "Lifo," and (4) the market price methods. With the average unit price method, each requistion is priced at the weighted average cost of the material on hand. The advocates of this method believe that the use value of each piece of a given material remains the same, regardless of when it was bought, and that it is therefore incorrect to make a higher material cost charge on one order than on another merely because of fluctuations in prices. The price and cost columns under the "On Hand" heading on the Barth sheet are intended for use with this method. When the purchase order routine has been completed and the invoice has been approved for payment, the purchasing department forwards to the balance of stores department a memorandum giving the quantity on the order, the unit price of the material, the total cost, and any other information that may be required. From this memorandum the ledger clerk enters in the "On Hand" column the price and cost information opposite the quantity received on the order. The quantity on hand previous to the receipt of the new shipment is multiplied by the old average unit price and its cost is extended. A new average unit price is then computed. The ledger clerk enters this new average unit price on each subsequent requisition until the receipt of another shipment changes the average unit price. If the material is obtained from the shop on a production order, the unit and total cost will be supplied by the cost department, but otherwise the procedure is the same.

The term "fifo" merely means "first-in-first-out." As in the previous case, the balance of stores section receives from the purchasing department a memorandum of the unit price and total cost of an order for a given item of material. This information is entered on a ledger card or sheet. As the ledger clerk receives requisitions for the material, he prices them at the unit price of the oldest order on hand. When the quantity on this order is used up, subsequent requisitions are deducted from the next oldest order, and are priced at the unit price of that order. This may be considerably different from the preceding price. It may be said in favor of fifo that in good stores practice the oldest material is always issued first. The material cost of an order tends to approximate the actual cost more closely.

Actual costs, however, may lag badly replacement costs in a rising market.

"Lifo" has had widespread use in recent years for this reason. This term means "last-in-first-out." Materials requisitions are priced out at the unit price of the last order received. The materials costs of an order more nearly reflect the replacement cost of the materials used. Lifo tends to inflate costs and understate profits during a period of inflation. The reverse tends to be true, of course, during a period of deflation.

With the market price method, the stores requisitions and credits are priced at the market price of the material at the time it is issued. Every month, or more often if necessary, the purchasing department submits to the balance of stores department a list of the current market prices for the items of purchased material carried in stores. When material is purchased, it is charged into the inventory controlling accounts of the general ledgers at the invoice price, and as it is issued it is credited to these accounts at the market price. The unit prices on the stores ledger sheets, at which all requisitions and credit slips are priced, are the current market prices. The physical inventory taken at the close of a period is also priced at these prices. The market value of the inventories on hand, less the balance of the inventory controlling accounts, is the profit or loss which has resulted from the purchasing department's transactions. The objection to the market price method is that management may be tempted to use the purchasing department for the purpose of acquiring speculative profits. This method is related to Lifo. It is less common, however.

Inventory Controlling Accounts

Inventory controlling accounts may be classified broadly as general stores of direct and indirect materials, worked materials, component parts stores, finished stores, salvage stores, and unclassified stores. As a rule, inventory controlling accounts are set up by the accounting department in the general ledger on the basis of some such classification. These summarize the accounts in the stores ledgers for the individual items of material. Worked materials are partially completed parts or assemblies in most cases. Work in process is usually not put into stores. The work in process accounts are chiefly the cost records. Plants which carry large and varied inventories will have a number of controlling accounts in each of the general classifications indicated above. Figure 19.4 shows part of such a classification. When the inventories have been properly classified and a good symbol system is used, filing the sheets or cards in the stores ledgers by the materials symbols automatically groups them into the controlling accounts in which the individual items fall. These accounts are more than

THE BUCKEYE STEEL CASTINGS COMPANY
Columbus, Ohio

CLASSIFICATION OF RAW MATERIALS AND STORES INVENTORY FOR CONTROL PURPOSES

MELTING STOCKS

Pig Iron
Purchased Steel Scrap
Shop Scrap
Ferro Manganese
Ferro Silicon
Spiegeleisen
Silico Manganese
Silicon Pig Iron
Nickel
Iron Ore
Molybdenum
Deoxidizing Aluminum
Other Melting Stocks

FURNACE MATERIAL

Fluxing Lime
Manganese Ore
Other Furnace Materials

FUEL

Steam Coal
Producer Coal
Fuel Oil

PURCHASED ASSEMBLY PARTS

Bolts
Bushings
Lids - Journal Box
Links
Pins
Plates
Other Assembly Parts

SPARE PARTS

Gears, Pinions, Sprockets and Worms
Wheels, Shafts and Bushings
Rough Castings - Steel, Iron and Brass
Other Spare Parts

MISCELLANEOUS STORES

Lumber
Brick and Masonry
Pipe and Fittings
Electrical
Iron, Steel, Brass and Copper - Bars, Sheets and Shafting
Structural Steel
Foundry, Core and Finishing - Bulk Supplies
Other Miscellaneous Stores

LID/hdh
7-18-56

Fig. 19.4. A Classification of Inventory-Controlling Accounts. (Courtesy, The Buckeye Steel Castings Co.)

mere summaries. Analysis of their trends, the ratios of the total of each account to sales or work in process, the turnover rates for each class of material, and similar comparisons are extremely valuable in determining current inventory policies, and in exercising an administrative control of inventories.

As the ledger clerk receives the material requisitions and credit slips

from the stores department, he sorts them by symbols, enters them in the ledgers, and prices them as previously explained. He then turns them over to clerks who extend the cost of each requisition or credit slip. The correctness of the extensions should be checked by other clerks, who also take off the total for each controlling account. The requisitions for each account are bundled together, with a memorandum showing the total value of those in each package, and forwarded to the accounting department. The credit slips are handled in a similar manner. The accounting department checks the totals for each bundle and posts them to the proper controlling account. There are now certain credits to the accounts of certain general classes of materials. When materials are purchased and received, the invoice for the order is checked and the transportation charges are usually prorated against each item. The purchasing department forwards the necessary evidences of the transaction to the accounting department, which debits the purchase cost of each item to the proper controlling account. The balance in a controlling account, modified by certain adjustments that are usually necessary, should represent the dollar value of the inventory on hand for the particular class of materials. In the case of finished parts and products, the cost department usually sends a cost memorandum to the general ledgers section when a production or assembly order is finally closed out; otherwise the procedure is much the same.

As a rule, the requisitions and credit slips are forwarded to the cost department later; here they are resorted according to the order number on each one. These slips may then be posted to a cost card for the order, if order costs are being kept.

Units of Issue

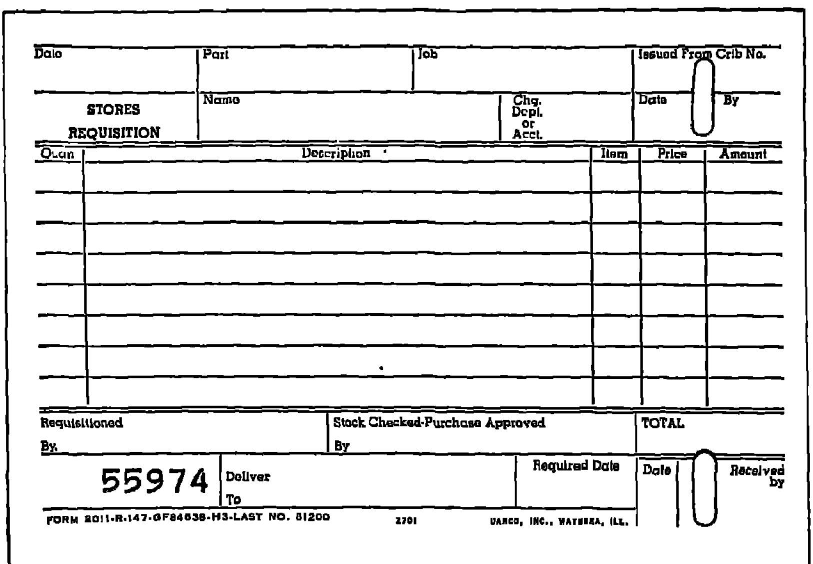
On the ledger sheet in Fig. 19.3 is the term "Kind of Unit"; this refers to the unit of issue. To illustrate, certain kinds of steel may be bought by the pound, but may be issued to the shop by the foot. Obviously, the unit price on the ledger sheet must be in terms of the unit in which the material is issued. This means a conversion of units which introduces a certain unavoidable amount of error. Again, economy in handling in the storeroom may make it inadvisable to issue individually small items of low unit value. For instance, it may be better to put up and issue small screws in lots of 25 than to fill requisitions for odd numbers. Otherwise, the time that the stores clerk would take to count out the screws would be worth more than the value of any screws that would thus be saved. The unit price of these screws on the ledger sheet would be the cost of 25 screws. The intermediate objectives of any procedure are economy and

effectiveness in its performance; however, they must be determined with proper regard for all expenditures of time, money, or other material resources that are necessary.

The Material Requisition

The material requisition, or stores issue as it is sometimes called, is the written authority for the withdrawal of material from stores. It transfers the responsibility for the material from the stores department to some other department and charges the material to a particular order or account. It may originate chiefly from two sources: the production control department or an authorized department head. The first has been discussed previously. Department heads can usually requisition such expense materials as their organizations may require. For example, cotton waste used in cleaning machines is requisitioned by the shop foreman as needed.

When the requisition is received in the stores records section, the ledger account for the material is credited; another account elsewhere is charged. To illustrate, if the material is for a production order, the requisition when received by the cost department will be the basis for an entry on the cost card for that order. Figure 19.5 shows a material requisition



STORES REQUISITION

Date | Part | Job | Issued From Crib No.

Name | Chg. Dept. or Acct. | Date | By

Quan	Description	Item	Price	Amount

Requisitioned By | Stock Checked-Purchase Approved By | TOTAL

55974 | Deliver To | Required Date | Date | Received by

FORM 2011-R-147-GF84638-H3-LAST NO. 81200 2701 UARCO, INC., WATSEKA, ILL.

Fig. 19.5. A Requisition for Direct Materials. (Courtesy, The Excello Corporation.)

and indicates the information usually called for. A material symbol usually identifies the material and the account under which it is carried in stores.

The location of the material in the storeroom may be shown by a location symbol. The location symbol may be entered on the requisition when it is received in the stores department office. This symbol facilitates the work of the stores clerks in filling the requisition. The storeroom may cover a considerable area, and there may be hundreds of bins which contain materials of all kinds.

In the case of material for production, the production control department, in preparing an order, may enter on the material requisition the department to which delivery is to be made, and the date thereof. After the requisition has been apportioned, it may be forwarded directly to the stores department. It is filed here in a tickler file against the delivery date. On this date, it is removed from the file, filed by the stores clerks, and delivered to the department by the internal transportation system. When the material is received, the requisition is receipted by the shop foreman and returned to the storeroom, which forwards it to the balance of stores department. In the "Charge" space is entered the order or product account symbol to which the material is to be charged.

The Stores Credit Slip

When all the material withdrawn for use on an order is not consumed, it should be returned to stores with a stores credit slip. This credits the order for which the material was withdrawn and charges the stores ledger account for it. A more common occurrence is the delivery, to stores, of finished component parts or finished product. In this case, the stores ledger account for the item is charged and the work in process account shown by the order number is credited. The stores credit slip contains information similar to that on the material requisition, and is handled in much the same manner. The credit slip for worked material is usually so designed that it can be easily distinguished from the ordinary credit slip.

Handling Unclassified Material

Unclassified stores includes all material not stocked regularly by the stores department. For example, a piece of machinery for the shop or equipment for the office may be purchased. Such items will probably not be carried regularly in stock. The supply division is responsible for unclassified items from the time of their receipt until they are delivered to the department for which they were ordered. But when, in cases like this, another shipment of the same item may never be received again, it is obviously a waste of time to make out a ledger sheet for it. Since the receipt and disposition of all material purchased by the plant must be recorded, some concerns use a copy of the purchase requisition as a ledger sheet for

unclassified purchase material. A printed form on the back of this copy, showing the receipt, quantity, value, and disposition of the material, enables it to be substituted for the regular ledger sheet. For the most part, unclassified material is not held in the storeroom for any length of time, but is moved as quickly as possible to the proper department in order to get it out of the way. Unclassified manufactured material may be handled similarly by means of a copy of the manufacturing requisition.

Physical Inventories

In order to take inventory, many concerns close down annually or semiannually for periods ranging from two days to two weeks, depending on the size of the plant and the thoroughness of the inventory. During this period, a count is taken of all materials, supplies, and work in process. While an inventory is never exactly accurate, it may be necessary for income tax, banking, and other purposes; furthermore, it offers an opportunity to reconcile the physical inventory with the book inventory shown in the "On Hand" columns of the stores ledgers.

Inventory Control with Continuous Manufacturing

The problem of inventory control in continuous manufacturing may differ greatly from the problem with intermittent manufacturing. The differences may be due to differences in manufacturing environment. This is particularly true of direct materials. Methods for controlling expense materials usually represent merely a further differentiation of the inventory methods discussed above.

With highly continuous manufacturing, a large volume of direct materials usually has to be handled and controlled. The concept of economic ordering quantities does not apply to such materials, under these conditions. If a material requisition were necessary for every delivery of these materials from stores, the clerical expense involved would be extremely great. Furthermore, success in continuous manufacturing usually depends on the maintenance of low floats and high turnovers for inventories. In continuous manufacturing, plant floats for direct materials may range from a two-day to a two-week period; it would be the exception, usually, for a concern to have a two-month supply of any part for current production. This policy of high turnover and low floats makes necessary prompt information on the amount and condition of inventories. Hence it is evident that under these conditions the objective in setting up an inventory procedure for direct materials is to make possible a fast, accurate control of inventories without the expense of stores ledgers.

When the work has to do with the completion of a succession of iden-

tical or very similar projects over a long period of time, and working conditions and procedures can be highly standardized, the general condition of performance approaches a continuous flow of work. Under such conditions, it is more effective and economical to control the rate of flow of completed projects from each operation or step in the procedure than to control the rate of progress of each individual project through these operations. Supply is a service function for production. The flow control usually applied to production in highly continuous manufacturing requires that a continuous flow of direct materials into each plant of the factory be correlated directly with the flow of production required from each one. As we have seen, this is determined ultimately by the forecast flow of demand for our products. Hence it is evident that in highly continuous manufacturing the flow control principle should be applied to the control of direct inventories.

To do this, there must be a demand schedule on which delivery schedules for the purchasing department can be based. It must be possible to determine for each material the required rate of flow into and through the plant. A well-organized internal transportation system is necessary. This system should be mechanized wherever possible. Such mechanization facilitates the continuous, speedy movement of materials through predetermined channels from which they cannot depart easily. All reports on the receipts and use of materials should be stated in cumulative totals because they are the best mathematical representation of a continuous flow. Given this information in sufficient detail, the inventory position for direct materials can be controlled without inventory control records. Some criteria of what this inventory position should be are necessary. These criteria are usually supplied by the standard stores and factory floats.

A simple example of the general procedure may aid in clarifying the relationships between these inventory control functions and factors in highly continuous manufacturing. It is assumed that our hypothetical part X is made from a forging that is purchased from an outside source. These forgings are delivered directly to plant D's receiving dock. These are completely machined in plant D for final assembly. Experience indicates that for this part the plant should maintain a 2-day factory float and a 3-day stores float. Its production requirements are approximately 2000 pieces per day. The plant storekeeper has reported an apparent shortage of part X; His stock of this part has been run down to approximately a 2-day supply. A check-up with the purchasing department on deliveries of these forgings to the plant, and with the plant production control office for deliveries from the plant, gives the following information:

Cumulative total deliveries of forgings to plant D		100,000 pcs
Cumulative total shipments from plant D:		
To the assembly plant	72,000 pcs	
Scrap	2,000	
To parts and service	8,000	
To sundry requirements	11,000	93,000 pcs
Inventory on hand		7,000 pcs

$$\text{Float, factory and stores,} = \frac{\text{Inventory}}{\text{Rate of Consumption}} = \frac{7000}{2000} \text{ or } 3\tfrac{1}{2} \text{ days}$$

Plant production control records show a 1½-day float in the shop.
Stores float: approximately 2 days, which checks.

The difficulty is apparently not due to excess deliveries to the shop. An extra shipment of forgings must be brought in as soon as possible. The causes of the shortage may be the vendor's failure to maintain deliveries in accordance with his schedule; a shipment in the yardmaster's hands that has not yet been moved up to the receiving dock; an increase in the plant's production schedule without a corresponding increase in the purchase delivery schedule; a higher rate of scrappage or sundry deliveries for the part than was anticipated. Other alternative solutions may suggest themselves. The various possibilities must be checked until the difficulty is located and corrected. Occasionally it may be necessary to take a floor check of the shop inventory of the part.

The plant storekeeper and his assistants have an important part in inventory control. It is their responsibility to check inventories constantly to protect the plant against shortages. To enable them to do this quickly without stock records, material may be delivered from the plant's receiving department in standard containers or tote boxes which hold a definite quantity of material. A prescribed number of these containers may be stored in standard racks. Bulk material may be piled in floor storage, a standard number in a pile. The storekeeper, knowing how many boxes or piles of material constitute his required float, can tell at a glance whether he has them. This is merely an application of the principle of physical minimums. Whether he reports the apparent shortage to the plant control office or to the general storekeeper's office depends on the setup of the concern. Staff assistants in the latter will probably investigate the causes of any serious shortage.

Under highly continuous manufacturing, inventory control may be extremely accurate. For example, the general storekeeper in one large automobile concern stated that the book inventory of direct materials,

computed by the above methods, checked with the annual physical inventory with an error of less than 5 percent. This method is economical because it eliminates the paper work of a ledger control. However, it cannot be used in intermittent manufacturing because the conditions required for it are absent. In consequence, it is one of the many economic advantages offered by large-scale continuous manufacturing.

PROBLEMS

1. The forecast annual sales of the company are $20 million per year. The estimated usage of a particular class of direct material, during the coming quarter, is $80,000. This class of inventory constitutes normally 2.0% of the total value of our inventory. It is expected that we shall end the current quarter with a $75,000 inventory of this material. The standard turnover ratio for this class of material is 4 turns per year. The National Association of Purchasing Agents has reported that a majority of purchasing agents are following a 60-90 day policy. It has been decided that a 75-day coverage at the end of the quarter will give us adequate protection for this class of material at this time. The normal sales-inventory ratio for this company is 5 times, on an annual basis.
   (a) How much can we buy during the quarter, if we are to maintain the standard rate?
   (b) How much can we buy, if we are limited to a 75-day coverage at the end of the quarter?
   (c) How much can we buy and maintain the normal sales-inventory ratio at the end of the quarter?
   (d) What is your decision concerning the purchase limit for this class of material that should be set? How did you arrive at it? Can we manage a business by mathematics? Are there any intangible factors in this problem that might affect your decision?
   (e) The individual items of materials that are represented by this controlling account are physical things: We do not store dollars in our warehouse. How would you convert your dollar estimates to physical units? Would you issue a purchase order to a vendor for the physical requirements of a particular item of material, in this classification, corresponding to the purchase limit that you have authorized?
2. A purchased part, No. 2176, was used as follows: 8000 units in November, 7000 in December, and 6000 in January. The company expected the declining trend in its business to continue during February and to be reflected in a continuing decrease in the use of Part 2176. Following its usual policy of ordering about a month's supply of parts, the company set the maximum ordering quantity at 5000 units, and the reorder point at 1000 units. An inventory was taken on February 12, all apportioned requisitions having been filled prior to this date. On February 27, the ledger sheet for Part 2176 showed the following transactions subsequent to February 12:

   2/12 Inventory, 4000 units. Unit price $0.25.
   2/12 Unapportioned requisition for S.O. 112 for 500 units.

2/13 Requisition apportioned for 900 units for S.O. 252.
2/15 Requisition apportioned for 1000 units for S.O. 278.
2/16 Unapportioned requisition for 500 units for S.O. 198.
2/18 Requisition apportioned for 800 units for S.O. 297.
2/20 Purchase Order 3170 for 5000 units posted.
2/21 900 pieces issued for S.O. 252 on requisition previously apportioned.
2/23 Requisition apportioned for 2000 units for S.O. 301.
2/24 3000 units on P.O. 3170 reported delivered.
2/24 Requisition apportioned for 2500 units for S.O. 320.
2/25 Unapportioned requisition for 200 units for S.O. 210 posted.
2/27 1000 units issued for S.O. 278 on requisition previously posted.
2/27 Price notice received from the purchasing department showing a unit purchase cost of $0.30 for the 3000 units received on P.O. 3170.

(a) Sketch a Barth-type ledger form, and enter the above transactions on it.
(b) What was the physical and dollar inventory of this part on February 27?
(c) What quantity of this item was available for use on new orders?

3. Part 1280 is manufactured to stock and is used at the rate of about 200 pieces per year. Most of the work on this piece consists of hand operations. The total preparation cost of manufacturing it, including setup charges, is $750.00. The time required to finish a lot of these pieces is the equivalent of a manufacturing rate of approximately 15,000 pieces per year. An order is run through as a single lot, and therefore finished pieces are not available for stores or assembly until the complete order is processed. The finished pieces are stacked in piles of 10 in the storeroom, each pile requiring about 3 square feet of floor storage space. The accounting department's charge against the stores department is at the approximate rate of $6.00 per year per square foot of net floor space. The standard cost of the piece is $50.00. The factor Z is 0.3.
   (a) How many pieces should be ordered?
   (b) Would you classify your decision as routine planning or creative planning? Why?
4. A certain material is used only in making Part 1570. The unit requirement is 1.087 lb for each piece. This part is made in Plant A. It is used in sufficient quantity to warrant setting up a production line for its continuous manufacture. The material is shipped directly to the storeroom in Plant A. Production reports show a cumulative total shipment of 106,000 pieces of Part 1570 to a subassembly line in Plant E, and also a cumulative total of 4130 pieces rejected by inspection. The part is produced at a scheduled rate of 6000 pieces per day. The standard stores float for the material is 6 days. The total plant float, including stores, is 10 days. Receiving department reports show a cumulative total delivery of 220,000 pounds of it by the vendor.
   (a) In what condition is the inventory of this material?
   (b) What are the possible causes for this condition?

CHAPTER 20 •

• Purchasing and the Supply Function

The Work of Purchasing and its Significance

THE volume of purchases in the United States has represented approximately 37½ percent of the gross national product in recent years. There has been a tendency of this proportion to increase. This has been due to a number of causes, including automation. Mr. Stewart Heinritz has estimated that purchasing expenditures take between 35 and 75 cents of every sales dollar, depending on the nature of the business.[1] The United States Steel Corporation buys approximately 40,000 different commodities that are supplied by 50,000 vendors. The cost of all products and services bought in 1954 represented approximately 37 percent of total business costs and 35 percent of sales. The relation of these expenditures to other business expenses is shown in Table 4.[2] Mr. John A. Hill has noted that

Table 4. U. S. Steel Sales, Costs, and Income in 1954

Item	Total in Millions	Percent of Sales
Receipts from customers, the public	$ 3250.4	100.0
Disposed of as follows:		
Total employment costs	1387.0	42.7
Products and services bought	1134.3	34.9
Wear and exhaustion of plants and equipment	261.8	8.0
Taxes	266.7	8.2
Interest charges	5.2	0.2
Dividends	110.7	3.4
Income invested in the business	84.7	2.6
Total disposition of receipts	$ 3250.4	100.0

[1] See AMA *Management News*, May 1954, p. 6. Mr. Heinritz is editor of the magazine *Purchasing*.

[2] Paul V. Farrell, and Dean S. Ammer, *Buying at United States Steel*, U.S. Steel Corporation Technical Paper 68. Reprinted from *Purchasing*, May 1955.

"in some manufacturing companies, purchases absorb about 50 to 60 percent of the sales dollar. A saving of 5 to 10 percent in the cost of purchases, therefore, is equivalent to 2½ to 5 percent of the sales dollar. An addition of this size to company profits would enable many companies to double their dividends to stockholders."[3] Purchasing agents have emphasized the point, in recent years, that purchasing is not merely a service function; that it is a profit-making activity. This is true, however, of any activity, line or staff, that can contribute directly and significantly to cost reduction. These agents have insisted that the head of the procurement and supply organization should rank with the heads of the sales, manufacturing, and financial divisions of the company. This has happened in some large concerns. It represents, however, a certain definite stage in staff evolution. Neither profit-making ability through cost reduction nor staff elevation to a top management level can change the nature of a function from staff to line. They can and do indicate, in this instance, that purchasing is a primary staff function whose importance in the organization has been increasing rapidly in recent years.

The functions of the purchasing department are to procure by purchase the proper quantities of what is wanted, for delivery at a certain time and place, at the lowest price consistent with the requisite quality. The determination of what is wanted involves the kind of material and the quality needed. The modern purchasing department has on file copies of all standard specifications for purchased materials; and these two factors are decided in most cases by materials specifications, which may be modified, however, on advice by the supply division to accomplish cost reductions. The quantity to be purchased may be governed by the production program, by economic purchase quantities that are determined on the basis of the balance of stores department's records of use, or by the specific needs of certain executives. In specifying delivery dates, the purchasing department may be guided by the production program, the trends of prices and supplies, the dates when specific orders are scheduled to start, or the normal usage of the stores department. This depends on the methods in use and the nature of the material to be purchased. In the matter of price, the lowest quotation is not always the cheapest. The quality of the material offered may not meet the specifications, its properties may make it impossible to process it economically, or delivery

[3] John A. Hill, President, Air Reduction Company, Inc., in a speech entitled "The Purchasing Revolution," delivered before the annual convention of the National Association of Purchasing Agents, May 25, 1953.

dates may not be satisfactory. These and other reasons may make it advisable to reject the lowest bid.

The Purchasing Department

The purchasing department operates under the supervision of a purchasing agent in Fig. 19.1. He reports to the procurement and supply manager. His position depends to some extent on the type of the concern and the nature of its purchasing problems. Thus, in an organization that uses large quantities of speculative materials, he may be an extremely important executive who works almost completely on his own initiative. The small plant's purchasing agent may be little more than a clerk who buys on the order of authorized executives. There are all degrees of executive importance between these extremes. However, in a plant of any size in which the purchasing function has been properly developed, he is a major staff executive. He may get substantial assistance from other staff groups in the supply division or outside of it. This agent must still be an expert on markets and materials, and must have a practical knowledge of economics, particularly the characteristics of price movements and supply, so that he can properly advise the plant executives on purchase policy. He must have executive ability and be competent to supervise the work of purchasing.

In large organizations, the purchasing agent usually has an assistant purchasing agent who relieves him of the routine work of supervising the department. The principal chain of command in the department extends from the purchasing agent, through the assistant purchasing agent to the buyers, or groups of buyers under a section chief. These buyers are usually specialized in the purchase of assigned classes of commodities. They are responsible for locating sources of supply, securing bids on orders, interviewing salesmen, placing purchase orders, etc., subject to the approval of the purchasing agent or his assistant.

There is usually a purchase control section of some kind. It may include record clerks who keep up to date the files of material specifications, vendors' files, quotation files, purchase order files, catalog files, and other records used by the department. This section may also include a follow-up unit whose clerks schedule and follow up purchase orders and shipments. This unit insures that materials ordered will be received on the date promised. There may be an invoice unit whose clerks check the invoices against the purchase orders and the receiving department's reports. They certify their correctness to the purchasing agent for approval for payment.

Such a department may seem unduly large and complex. Not long ago

the foreman or superintendent of a department or shop purchased the materials and supplies which he needed. This procedure is still followed occasionally in small plants. Such methods are not found in the better-managed plants. Unless the work of purchasing is centralized in the hands of a trained staff, great losses may occur that will more than offset any saving possible from economizing on this department. The trained purchasing agent and his buyers are familiar with the product and its requirements. They are in a position to see the purchasing problems of the plant as a whole, and therefore to exercise the greatest economy. They know markets and price cycles, which the average department head does not. They are familar with the various sources of supply and with the character, capacity, and ability of the different vendors. They understand the advantages and characteristics of the various kinds of purchase contracts and techniques. For these and other reasons, their services will return large savings to almost any company.

Procurement Planning and Research

Procurement planning and research functions have to do with the development of standards and plans for greater economy and effectiveness in the work of procurement and supply. Its objectives, as indicated, are greater economy and effectiveness. These functions include such values as a lower cost of purchased materials; technical assistance that will free buyers and other divisional personnel for better performance of their principal functions; a lower investment in inventories in relation to sales; better purchasing and supply methods, and others. The planning and research organization is a staff department. It is attached, in Fig. 19.1, to the principal chain of command of the supply division, under the supply manager. The head of the department therefore has only staff responsibility for the accomplishment of the above objectives. His policies for the operation of his department should be based on those principles that govern staff operations and relationships anywhere. The importance of his function is indicated by the savings that it can accomplish, in coöperation with other departments. It is reported, for example, that the Westinghouse Electric Corporation saved $19 million in 1953 and approximately $25 million in 1954, through such planning and research.[4]

The functions of the procurement and research department are those, within the scope of its mission, which the director of procurement and supply assigns. These may include such activities as the recommendation

[4] Joseph M. Guilfoyle "Westinghouse Shows How to Slash Spending on Materials, Parts," *Wall Street Journal*, October 12, 1954.

of objectives and policies for the supply division. This may require: (1) procurement cost analysis, (2) market research to determine price and supply trends, (3) the study of quality standards in coöperation with the quality manager's organization, (4) the development of inventory plans and standards, (5) the determination of economical ordering quantities, (6) the development of better procedures for procurement and supply, and (7) coöperation with vendors in price reduction. The general nature of the supply divisions objectives has been discussed previously. They should be definitized, as far as practicable, in order that results can be measured against them. Purchase cost savings, for example, should be set up in the form of dollar goals for classes and major items of purchased materials. Accomplishment of these or any other objectives depends on the acceptance and application of sound policies by the organization. The planning-and-research group may be asked to study the problem of policy additions or changes, and to make recommendations to a committee that has been appointed to consider them. This can be illustrated by the problem of reduction in the purchase price of an important item. It will probably require the coöperation of the vendor. Coöperation requires friendly relations, based on confidence. Some companies have developed statements of purchasing policy that are designed to maintain fair, friendly relations between vendor and vendee.[5] The facts supporting cost-reduction decisions are obtained frequently by cost analysis. This data enables purchasing agent to answer such questions as: What are the items which have the largest dollar and physical volume of purchases? Which of these items could be made or sold by the vendor at a lower price, without sacrificing necessary quality or reasonable profit margins? How do our material costs compare with those of our principal competitors for corresponding parts in competing product models? The required information may be drawn from a number of sources. The group in Fig. 20.1 is trying to decide whether to buy or make the particular piece. Its members probably were drawn from the purchasing, product engineeering, and manufacturing methods departments, the comptroller's division, and the manufacturing line organization. The accomplishment of a price reduction by the vendor of an item requires the facts indicated and many more not indicated. This is true particularly when the reduction is beyond that which can usually be obtained through price comparisons and bargaining. It may be neces-

[5] Some well-known statements are the *Principles of Good Source Relations* of the Personal Products Division of Johnson & Johnson, the *Manual of Purchasing Policies and Principles* of Bigelow-Sanford Carpet Company, Inc., and *The Manufacturer and McKesson & Robbins* of McKesson & Robbins, Inc. There are other good examples.

Fig. 20.1. Shall We Buy or Shall We Make? (Courtesy, Cadillac Div., General Motors Corp.)

sary to have the industrial engineering division work out the manufacturing methods that should be used for maximum economy and required quality. The comptroller's division may have to estimate probable costs to make and sell the item at the vendor's location. Conferences with the supplier will be necessary to induce him to undertake the work of reducing the cost and price of the item. It may then be necessary for members of the vendee's staff to work with the vendor's staff, in setting up cost-reduction methods that are realistic in the light of the vendor's actual conditions. All contacts with the source of supply for an item should be handled through or with the knowledge of the buyer. The buyer would not have time probably to initiate and coördinate such cost-reduction projects.

Procurement planning can furnish a valuable service of technical staff coördination.

Market research for procurement is concerned with the forecasting of price and supply trends. Such market research information enables management to formulate intelligently policy governing inventory coverage. This may vary for specific classes and items of material from spot buying to 120 days, or more. This variation depends on market and business conditions. Information concerning such conditions is so important that the National Association of Purchasing Agents has a Business Survey Committee. It reports summaries of its surveys of member companies in the Association's *Bulletin*.[6] Market research for procurement is concerned also with sources of supply.

Procurement research may work with a buyer in the purchasing department and an analyst in the quality manager's organization in determining what are the economical limits of producer's risk and consumer's risk in setting tolerances for receiving inspection.[7] These limits should be stated in the purchase contract, if they are important. The buyer is usually responsible for negotiating the contract. It is evident that the procurement research and quality control organizations can have only advisory rights of decision.

The work of developing inventory plans and standards, and of determining economical ordering quantities has been discussed previously. This work can be assigned logically to a procurement planning staff. The same thing can be said for the methods used by the various departments of the supply division. An executive is responsible for the use of effective, economical methods by his organization. He should be able to request procurement planning and research, or some similar department, to make a study of a procedure that is causing trouble. He is still responsible if there is no such organization. This same executive must then develop his methods within the limits of his time and ability. Other duties of a planning nature may be assigned to the procurement planning and research department. The exact duties depend on the size of the company and the point of view of our chief procurement and supply executive.[8]

[6] For an analysis of this survey, see Dr. Heinz E. Luedicke, "Recession and Recovery—the Record of N.A.P.A.'s Business Survey Committee for 1953-1954," *Bulletin of the National Association of Purchasing Agents*, March 16, 1955.

[7] These terms were discussed in Chapter 18. See also "Quality Control of Purchased Materials: One Company's Program," *AMA Management Review*, May 1955.

[8] See "Purchasing Research, Its Prophets Aim at Profits" by George Melloan in the *Wall Street Journal* of September 14, 1954, and "A Description of the Analytical Approach to Industrial Purchasing" by Andrew M. Kennedy, Jr. in the March 1954 issue of *Advanced Management*, the journal of the Society for Advancement of Management.

None of the above duties is new. The gradual differentiation and assignment of them to a staff planning and research group is merely an example of staff evolution. The plant shown in Fig 19.1 must be a large organization in itself. Otherwise it could not afford a separate department or section for procurement planning and research. This plant is evidently a part of a large organization that is engaged in multiplant operation on a product-line, profit-center basis of decentralization. Smaller plants may have only a purchasing research section under the purchasing agent, or none at all. The purchasing department, in a small company, may consist chiefly of a purchasing agent and his secretary. The stores department may be a small organization under manufacturing. There is no distinct differentiation of the procurement planning and research functions in such case.

The P & R department, in Fig. 19.1, serves the various departments composing the procurement and supply division, as noted previously. It must also coöperate and coördinate with technical staff departments that are located in other divisions of the company. The work of the planning and research department falls primarily in the field of applied business economics, however. It may be allowed, consequently, a complement of accountants, business economists, and engineers in its table of organization, to enable it to perform its mission.

Standards and Control

The work of the P & R department may result in the establishment of performance standards for procurement and supply. It is not the function of the department to apply such standards to the control of divisional operations. The application of administrative performance standards, in Fig. 19.1, would be made by the control department under the supply manager. Operative standards should be applied within the departments to the operations to which they apply.

Speculative Purchasing

All purchasing involves buying for future needs. The distinction between speculative and routing purchasing has to do largely with intent. The former usually involves an intent to realize a speculative profit. The latter is concerned chiefly with obtaining required quantities of materials and supplies at a competitive price, as a basis for a manufacturing profit.

Speculative purchasing may be necessary for several reasons. Current supplies of certain of our basic raw materials may always be thin. It may be subject accordingly to wide price fluctuations. There may be no organized exchanges for these materials, such as there are for cotton, certain

grains, and other commodities. Otherwise, hedging operations to reduce both speculative profits and speculative risks may be engaged in. The customs of the industry and the nature of our competition may also be factors.

The purchasing agent who must engage in speculative purchasing must have great freedom of action and initiative, as far as the time and the amounts to be bought are concerned. Speed of action is often important, because a given commodity may be in a favorable buying position for only a relatively limited time. For these reasons, his actions may be subject only to the general inventory policy, the limitations of the materials budget, and the general supervision of a materials committee. Commitments in excess of maximum single amounts or budget limits usually must have the approval of a top administrative executive. The purchasing agent must be a shrewd, keen student of business and of the commodities that he buys. He should have the statistical assistance of some qualified agency in determining when a downward price movement has run its course and an upward movement is about to begin. The procurement planning and research department in Fig. 19.1 might be this agency. The purchase of speculative materials may be handled personally by the president of the company when large amounts of money are involved.

Most concerns do not deliberately engage in speculative purchasing, however, unless they feel that the procurement and supply situation for a purchased item demands it. The risks of overstocking and inventory losses are too great. The stockholders, furthermore, have presumably invested their capital for a manufacturing rather than a speculative profit.

Routine Purchasing and Its Control

The term routine purchasing usually refers to the work of buying classified materials on the authority of a purchase requisition that has been originated by the balance-of-stores or inventory control section. It is routine only in the sense that the buyer's discretion is limited by the specification of kind, quantity, and delivery that are requested on the requisition. These limitations are subject to modification when necesary, through conference with the requisitioning authority. The term "routine" does not mean that it is unimportant. The purchase of classified materials on requisition may be the principal work of purchasing in some manufacturing concerns. It may account for the bulk of the dollar volume of purchases. This is likely to be the case for both direct and expense materials in concerns engaged in intermittent manufacturing. It is not likely to be true for concerns engaged in continuous manufacturing.

The purchasing function serves directly the needs of the line organizations, as well as other staff groups, for materials and supplies. Its work therefore must be coördinated with the activities of these line and staff organizations, to the end that the materials will be available when needed. This means usually that the purchasing agent or the buyer must perform certain functions of purchase control, or have them performed for them by some control unit in the department. These control functions have to do primarily with coördinating purchase activities and with evaluating the performance of the vendor. Some of the control activities that enter into the purchasing department's control of its activities are the receipt and validation of the purchase requisition, the routine provision of purchase information, purchase follow-up and expediting, invoice checking and adjustment, and any other activities that have to do primarily with purchase control, rather than with the work of purchasing itself. We shall discuss such control functions in connection with the procedure for routine purchasing under conditions of intermittent manufacturing. The principal phases of the procedure are:

1. The initiation of purchasing through the release of purchase authority
2. Routine planning and preparation for purchasing
3. The negotiation of the purchase
4. The origination and release of the purchase order
5. The follow-up of the purchase
6. Completion of the contract by the vendor
7. The closure of the purchase project

The Release of Purchase Authority

Speculative purchasing requires a blanket release of authority, subject to certain broad limitations of inventory policy, materials budgets, and higher administrative supervision. In the nonspeculative purchase of direct materials for future needs, the production program may carry the necessary authority. This is true particularly of the procurement of direct materials for continuous manufacturing. Central manufacturing control in such case probably will break down the manufacturing program into a corresponding materials requirements program. The latter must be adjusted for production, stores, and purchasing lead time, or float. The nature of this adjustment will be seen shortly. Such programs usually require the approval of a higher administrative authority. The authority to purchase other classified or unclassified items is usually conveyed by a purchase requisition.

In intermittent manufacturing, purchase requisitions for both direct and

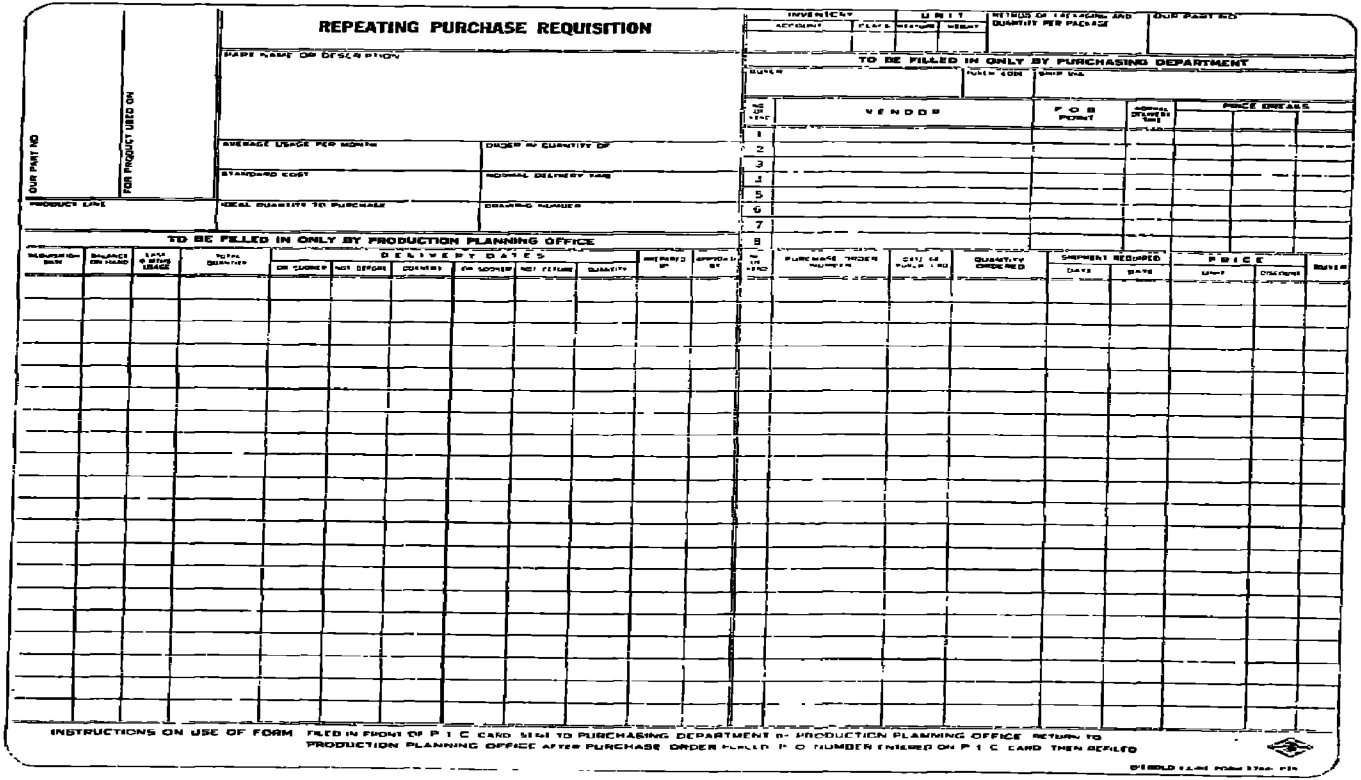
expense materials may originate in the stores records section, under production control. When the stock records show that the available stock of a particular item is at the reorder point, a purchase requisition is made out by an order clerk. As we have seen, this point should be so set as to allow the purchasing department sufficient time to secure a new supply. The quantity requisitioned should be the economical quantity to order. When properly approved, the purchase requisition conveys the authority to buy the kind and quantity of materials specified, for delivery as indicated.

The purchase requisition also expedites the purchasing process because it gives assurance that the purchasing department will receive promptly all the information that it needs. When a buyer has to telephone the requisitioner for information that the latter neglected to supply, a certain amount of delay is inevitable. This may prove to be very expensive in many ways. The purchase requisition in Fig. 20.2 shows the general nature of the necessary information.

Routine Planning and Preparation for Purchasing

The receipt of the requisition by the purchasing department initiates the routine of purchasing. The next phase of the procedure may involve such problems as the approval of the requisition, designation of the proper buyer to handle it, the routine provision of purchase information, and the routine location of sources of supply. An incoming requisition should be checked to see whether it is completely and correctly made out, whether the executive who signed it has this authority and the right to requisition the items listed, etc. Requisitions for unclassified items above a certain value, for example, may have to be referred to the purchasing agent—another application of the exception principle in management. The buyers in a large purchasing department are usually specialized to some extent—one may handle only fuels and maintenance supplies; another, steel and certain related items, and so on. Obviously the requisition should be routed to the buyer who usually handles the particular class of materials and is best able to take care of it. In the case of unclassified items, the load of work ahead of the various buyers usually has to be considered. If the requisition calls for a standard item, it may be routed through the records unit, which will attach the specifications for it.

The service objective of the purchasing department is to supply a purchase that will meet the requirements previously noted. The function that results immediately and directly in the achievement of the purchasing departments objectives is obviously the buying function. It therefore


REPEATING PURCHASE REQUISITION

OUR PART NO

FOR PRODUCT USED ON

PRODUCT LINE

AVERAGE USAGE PER MONTH

ORDER IN QUANTITY OF

STANDARD COST

NORMAL DELIVERY TIME

IDEAL QUANTITY TO PURCHASE

DRAWING NUMBER

INVENTORY

UNIT

METHOD OF PACKAGING AND QUANTITY PER PACKAGE

TO BE FILLED IN ONLY BY PURCHASING DEPARTMENT

BUYER

VENDOR

F O B POINT

PRICE BREAKS

TO BE FILLED IN ONLY BY PRODUCTION PLANNING OFFICE

BALANCE ON HAND

TOTAL QUANTITY

DELIVERY DATES

PURCHASE ORDER NUMBER

QUANTITY ORDERED

SHIPMENT REQUIRED

DATE

PRICE

UNIT

DISCOUNT

BUYER

INSTRUCTIONS ON USE OF FORM

Fig. 20.2. A Purchase Requisition and Recapitulation Sheet.
(Courtesy, Diebold, Inc.)

forms the principal chain of command in the department. The other departmental functions are secondary to it. The records unit of the purchase control section, for example, assists the buyers by supplying them with routine information on the quality required, the sources of supply, prices, the kinds of material available in the market, and other data relating to the economics of purchasing. To do this, it may maintain extensive records, such as specification files, materials files, quotation files, vendors' files, catalog files, purchase order files, etc.

A *materials file* accumulates, in usable form, information on each item or class of material that is purchased regularly. It states the customary sources of supply for each material. A form may be printed on a filing folder. General information, such as material name and symbol, specification number and description may be entered on this form. The name, address, capacity, normal delivery time by air, rail, or water, and ratings for quality and delivery service also may be entered. Information on new manufacturing methods, substitute material, etc. may be filed in the folder. Such information is forwarded by the buyers to the records unit for filing.

The quotation file is in almost universal use. Its purpose is to provide a continuous record of prices paid or quotations received for a given item over a period of years. A card is made out for each item of purchased material. The general information entered in a form at the top of the card is the same as that on the material record. Specific information on each purchase is entered in a form covering the remainder of the card. This information would include for each purchase of the material the date, purchase order number, quantity purchased, list price discounts, net price, transportation charges, total cost, unit cost, and the vendor's name or number. The prices of some materials such as copper, rubber, pig iron, and cotton, are quoted regularly in trade publications and elsewhere. The buyer, by following these quotations daily, is thoroughly informed regarding their price trends. But every concern purchases a great many materials that have no well-organized markets from which quotations can be obtained regularly. It is for such items that the quotation file supplies valuable information to aid the buyer in determining a fair price. Even in the case of raw materials which have broad, well-established markets, the quotation file may be very useful. For one thing, it provides a list of the usual sources of supply for a classified item in a form that is quickly available.

A large company may use many thousands of concerns as sources of supply. There may be a considerable variance between the quality of

the service rendered by different vendors. Some companies find it desirable, for this reason, to keep vendor's records. Certain general information may be entered on a form printed on a card or filing folder. This information has to do with the vendor's name, serial number, address, product lines, his credit rating, and rating of his service. The approximate capacity for the principal materials or products which are bought from him also may be entered. Certain specific performance information may be entered in a form below this for each order placed with the vendor. It usually would include the date, purchase-order number, material name and symbol, the quantity on the order, and a notation of the quality of the service rendered on the order. If a vendor fails to meet his promised shipping date, does not ship the goods in accordance with the directions on the purchase order, refuses to make reasonable adjustments, or for any other reason does not give satisfactory service, reference to this fact may be entered on his record, under "Remarks." There may also be a reference to the pertinent correspondence. The vendor's record is intended to supplement the usual sources of information regarding his reliability and ability to fulfill contracts; not to take their place. In the absence of a vendor's record, memory must be relied on largely. This may be sufficient, however, in a small purchasing office.

There are three basic procurement factors for which facts on the above records have been collected. These are the material, the price, and the source of supply. Some of these records may be combined nevertheless. The materials information and the quotation data, for example, can be combined in a single folder for each material. The vendor capacity and delivery-time data can be entered on the vendor's record. Any time that the number of records can be reduced, the overhead expense of record keeping can usually be reduced also.

Every purchasing department constantly receives catalogs and circulars of materials for which the company is normally in the market. These contain much information of value to the buyer, and sometimes indicate sources of supply not previously used. To prevent their loss and to keep them readily available, most well-organized purchasing departments regularly index and file those for which they have any use. A file clerk is held responsible for them.

All completed purchase orders are filed according to order number, after the essential information relating to the fulfillment of the contract has been entered on the order. This file has historical and reference value for the procurement planning and research group, as well as for the purchasing department.

Sources of Supply

Continued study of sources is necessary for classified items, even through the purchasing department has lists of accredited vendors. Financially strong sources may become weak in a relatively short time. A vendor's products which were formerly strong competitively may have lagged behind technological progress. Other reasons may make it desirable to change the source of supply. A purchasing agent is often required to secure unclassified items never purchased before. He may have difficulty in finding where they can be obtained. There are various sources of information, in addition to the catalogs, etc., mentioned above. Manufacturers' registers, associations of manufacturers or wholesalers, technical societies, chambers of commerce, and similar organizations furnish information concerning any of their members who can supply the material needed. The purchasing agent undoubtedly knows most of the leading purchasing agents in his community, particularly if he is a member of the local chapter of the National Association of Purchasing Agents. He may be able to get helpful suggestions as to sources by telephoning those who may have had to purchase similar items.

After suitable sources of supply have been located, it may still be necessary to solve certain problems of purchase policy. Should a given classified item be ordered from one or several sources? What policy should be followed when a subsidiary or sister division of the company is a possible source? What should it be with regard to sources that are weak, although conveniently located for purposes of supply? To what extent should reciprocity in buying enter into the selection of sources? This may be the determining factor for a manufacturer of railroad equipment or supplies. The railroads may insist that raw materials for such an order be purchased from plants which are located on their right of way, or which will ship over them. Thus it is obvious that the selection of sources involves something more than getting a vendor's address from a catalog.

The Negotiation of the Purchase

After the purchasing agent or buyer has been given the authority to buy and the necessary information, there still remains the negotiation of the purchase. If he is buying a gross of lead pencils, this may be insignificant; but if he is covering the coming quarter's requirements for some basic raw material, such as steel, it may be extremely important; a difference of a fraction of a cent per pound may run into many thousands

of dollars on the total quantity involved. This phase involves certain problems relating to the securing of quotations, their analysis, relations with salesmen, the conditions of negotiation and purchase, contracts and their use, etc.

The price at which an order is placed may be a negotiated price or a competitive price. A negotiated price is one that is the result of discussions of cost and price considerations between vendor and vendee, but without direct comparisons with the prices of competitive items. A competitive price is obviously the direct result of price comparisons between competitive materials. The latter is not always lower in terms of value received. The contributions of the procurement planning and research group to purchase cost analysis and reduction have been discussed previously. The result may be a substantial improvement in quality, a reduction in price, or both. The price is necessarily a negotiated price.

Negotiation has become a very important method of price determination for large corporations. This is particularly true for purchased parts, components, and possibly certain basic raw materials. A competitive price, based on comparisons of quotations, may be more economical when buying standard stock staple items. It may be more economical for the small manufacturer who does not have a large and attractive volume of business to offer. It may be more practicable for the manufacturer who does not have a procurement planning and research organization.

Requests for Bids

Requests for bids are sent out accordingly for many important purchases. However, when the plant's need for certain material is very urgent, this step may be omitted. A purchase order is made out and sent immediately to a vendor in whom the purchasing agent has confidence. Most concerns use a standard quotation or inquiry form, similar to that in Fig. 20.3; such a form insures greater uniformity between the bids submitted by the various vendors. The use of a standard procedure with a standard inquiry form affords greater assurance that the vendor will receive all the necessary information concerning the conditions of the purchase.

To reduce still further the possibility of misunderstandings, some inquiry forms are very similar to a purchase order form. There is the danger, however, that the vendor will regard the inquiry as an offer to purchase. If it may be so construed, his acceptance may create a contract. To avoid this possibility, some such statement as "This Is Not An Order" is often printed across the face of the form.

It may be advisable to include in the proposal various conditions of

acceptance of the vendor's offer to sell. For example, may the purchasing agent select only the lowest-priced items from the bids of the various vendors? Unless there is some definite statement to the contrary, the prices quoted may apply only on acceptance of the bid as a whole. How long shall these quotations remain in effect? Unless this is covered, the

White

No. 88324

THE WHITE MOTOR COMPANY

CLEVELAND 1, OHIO

THIS IS A REQUEST FOR QUOTATION NOT AN ORDER

QUOTATIONS WILL NOT BE CONSIDERED UNLESS RETURNED ON THIS FORM.

NO CHARGES TO BE ALLOWED FOR PACKING OR CARTAGE.

WE ARE TO HAVE THE PRIVILEGE OF ACCEPTING ALL OR PART OF THIS QUOTATION.

PRICES QUOTED ARE FOR SIXTY DAYS UNLESS OTHERWISE NOTED.

DEPARTMENT REQUISITION NO. BUYER STENOG. DATE QUOTATION MUST BE SUBMITTED NOT LATER THAN

QUANTITY	PART NO.	MATERIAL	UNIT PRICE		
			LIST OR BASE	DISCOUNT	NET PRICE

CAN YOU MAKE DELIVERIES AS FOLLOWS

TERMS ______ % ______ SIGNED ______

F. O. B. ______ DATE OF QUOTATION ______ PER ______

TO BE FILLED OUT AND RETURNED TO THE WHITE MOTOR COMPANY

Fig. 20.3. A Request for a Quotation. This is a "snap-out" form: Four copies can be typed simultaneously. (Courtesy, The White Motor Company.)

courts will interpret it in accordance with their understanding of what is fair and reasonable. Should quotations be f.o.b. shipping point or destination? Other things being equal, title to the goods usually changes at the f.o.b. point; this raises other questions.

In some instances, voluminous specifications have to be included in the inquiry. When it is impossible to type them on the inquiry sheet itself, they should be stapled to it and incorporated in the proposal by specific

reference, particularly if the return of the inquiry is to constitute an offer to sell.

As we have seen, delivery is often an important consideration in purchasing; it is a function of the transportation services used. The description of the material may affect its freight classification and hence the tariff. If it is shipped f.o.b. shipping point, the vendee of course pays the transportation charges, and any damage in transport is probably his loss rather than the vendor's. For these and other reasons, the inquiry is often routed through the traffic department before it is sent to the vendor.

Considerations like these enter into the origination of an inquiry. Typing and dispatching it to a vendor is the least significant part of the work.

Quotations

Sometimes the buyer must purchase an advertised article whose price is maintained. While he may be unable to better the quoted price, he may be able to induce the vendor to prepay freight, thus reducing the cost of the item. In general, secret rebates, unjustifiably large advertising allowances, excessive quantity discounts, and similar concessions made to large purchasers are now illegal. The Robinson-Patman Act provides that there shall be no unfair price discrimination between buyers of the same kind, quality, and quantity of goods. Hence quantity discounts are warranted only to the extent that large orders actually do result in real economies in production and distribution; furthermore, such discounts must be offered uniformly to the trade.

In considering bids, quotations must be reduced to a comparable basis. The buyer is often quoted the list price less certain trade discounts, as for example, list price less 10-10-5. This means that the purchaser may deduct a discount of 10 percent from the list or catalog price, another 10 percent from the balance, and 5 percent from this figure. One reason for such quotations is that they reduce the necessity for revising the catalog whenever there is a substantial change in prices. Most concerns also offer a discount for the prompt payment of bills; this is usually 2 percent for payment within 10 days, but it varies between industries in accordance with trade customs. Each vendor's quotations for each item, together with the pro-rata transportation charges, are listed on a recapitulation sheet, and the total unit purchase cost is computed. It may not always be advisable, however, to select the lowest bid, or any bid for that matter. What can be done when the lowest unit purchase cost is higher than the estimated cost which the purchasing department submitted to

the cost estimating section when current models were priced at the beginning of the season? There are several alternatives, such as calling for new bids, searching for cheaper sources, recommending substitute materials, purchase cost analysis for price reduction, advancing the price of the product, etc. The last alternative may be impracticable in a buyer's market.

Relations with Salesmen

Salesmen call regularly on the purchasing department as they cover their territories. An important request for a quotation usually results in additional calls and sometimes from their zone or regional superiors. This brings up the question of what constitutes proper relations between buyers and salesmen, and leads to the problem of purchase ethics. The application of ethical principles to purchasing is obviously a problem in purchasing policy. We shall merely point out that the salesman is usually the commercial representative of a reputable company. Regardless of the size of this concern, its representative is entitled to courteous, considerate treatment. This means, for one thing, that he should be kept waiting no longer than is absolutely necessary. He should have an opportunity to see someone in a position of executive responsibility in the purchasing department, if only an assistant buyer. It is not always shrewd business, furthermore, to take advantage of the salesman in a buyers' market. The purchasing agent does of course have an obligation to secure a favorable and fair price, but he is under no obligation to secure an unreasonable and unfair one. In a sellers' market, the advantage obviously is with the salesman. However, he is always in a position to inform the purchasing agent of impending price changes, changes of design, etc., and to give other valuable trade information; he can sometimes aid in expediting deliveries. These and other services are over and above the delivery of the specified materials in strict accordance with the contract. He is more likely to render them if the purchasing agent has his respect and friendship. Unethical practices associated with gifts to buyers, commissions granted on business, etc., belong to a technical discussion of purchasing.

Contracts

A purchase contract is a statement of the obligations created by agreement between vendor and vendee for the exchange of certain values, and the conditions governing the discharge of these obligations. Contracts may be written or oral, but in industrial purchasing they are almost invariably written. As his title suggests, the purchasing agent acts as a legal agent. He usually creates certain legal obligations for his company

whenever he consummates a purchase. He should have sufficient knowledge of the law of contracts and agency to know when he needs to consult the company's legal department. The type of contract and the nature of its price clauses may be a factor in purchase negotiations.

In general, purchase contracts may be classified as individual or blanket. The usual purchase order is an individual contract covering a particular shipment of material. Its provisions concerning price, time, delivery, and other conditions apply only to the shipment under consideration. The purchase order form is sometimes referred to as a short form of contract.

The blanket contract provides usually for the delivery of a supply of material over an extended period of time. It is used when a concern wishes to cover its material requirements considerably in advance of manufacturing. This contract insures an adequate supply of material for the plant, regardless of conditions in the open market. To illustrate, it will be assumed that a certain company is a heavy consumer of a commodity whose price has been declining steadily for several months. A study of market conditions has convinced the purchasing agent that, instead of going much lower, this price will shortly start upward. This movement will probably continue for an extended time in the future. The purchasing agent may recommend to the materials committee that it authorize the forward buying of the commodity. If his recommendation is approved, the purchasing agent will probably place contracts for a quantity sufficient to meet the plant's needs for the coming manufacturing period, or longer if this seems advisable. In such a case, a flat price will probably be established for the contract. Shipments may be made either when released by suborders issued under the contract, or in accordance with delivery schedules issued periodically. Blanket contracts are frequently written in long form because large amounts of money may be involved. This means in complete legal detail.

Contracts differ also with regard to their price clauses, the most familiar being the flat-price contract, the cost-plus contract, the market at time of shipment contract, and contracts with various penalty clauses. In the flat-price contract, the price agreed on by the vendor and the vendee applies to all shipments made under it. If the price of the item goes up the vendee profits thereby; if it drops he suffers.

Under the cost-plus contract, the buyer agrees to purchase at the cost of producing the item, plus an agreed-upon percentage of profit; he has the right to inspect the seller's books to verify the cost statements. This type of contract was common during World War I and postwar periods. The prices of materials and labor were advancing so rapidly that it was

impossible to make cost estimates that could be relied upon for any length of time. On the surface, this arrangement appeared to be perfectly fair, but it frequently leads to abuses. For example, it gave the seller an incentive to increase rather than decrease costs; this can be done in so many ways without any such intent showing in the costs records that the buyer is likely to suffer unless the seller is unusually honest. A variant of this form of contract was used during World War II. It was known as the CPFF (Cost-Plus-Fixed-Fee) contract. The vendor was allowed a profit at an agreed rate on his original cost estimate. He was reimbursed for his allowable costs, regardless of the original estimate. His profit on the contract was limited, however, to the amount originally allowed. There was little incentive, in consequence, to increase costs unnecessarily. There was little incentive, on the other hand, to manage economically. This form of contract was used by the Armed Services in many cases. Its use was frequently necessary when a manufacturer was required to make weapons or other war materiel with which he had had no previous production experience. This materiel, in some cases, had been only an idea in some laboratory just a few months previously. The CPFF contract is sometimes used by private industry for outside experimental or developmental contracts.

The purchase contract may read "market at time of shipment." This method of price determination may be used in connection with blanket contracts. It means that shipments as released under the contract are priced and billed to the company at the current price quoted by an agreed-upon source. This arrangement insures that the plant will have an adequate supply of material when needed, and precludes the possibility of a speculative loss because of falling prices, except as the result of competition from other manufacturers who have bought or sold successfully on the market.

Penalty clauses in purchase contracts are usually intended to insure delivery when promised, or quality within the limits prescribed by the material specifications. Because a delayed shipment often results in costly delays to production, the contract may contain a penalty clause that permits the purchaser to make certain graduated deductions from the invoice, depending on the length of the delay beyond the delivery date. Of course, failure to meet the promised date usually gives the purchaser the right to cancel the contract. In some cases, penalty clauses have been included that entitle him to make deductions from the invoice for articles in the shipment that fail to meet the standards of quality agreed upon in the purchase contract. Much of our product inspection today involves sampling. There is some risk, accordingly, that some items of

product in a shipment will not be within the agreed tolerances for one or more quality attributes. The concepts of "allowable percent defective" material, "consumer's risk," and "producer's risk" were discussed in connection with quality control. It is evident that any allowable percent of defective material should be stated in the purchase contract. In general, a penalty clause can only compensate for damages actually resulting from the vendor's failure to comply fully with the terms of the contract; it cannot be purely punitive.

The Purchase Order

The next general phase of the purchasing procedure has to do with the origination and release of the purchase order. The most favorable quotation, in view of delivery, quality, service, and price is selected. The buyer writes a purchase order. It is forwarded to the vendor, after approval by the purchasing agent. If this order is issued in response to an offer to sell, a contract is effected. It is merely an offer to purchase, otherwise. It does not become a contract in such case until it has been formally acknowledged and accepted by the vendor. Some purchasing departments have a special acceptance form which is attached to the purchase order; this is filled out and returned by the vendor upon receipt of the order. Several copies of the purchase order are usually made; these are distributed to the various departments and individuals concerned, such as accounting, receiving, the follow-up section of the purchasing department, stores record section, the invoice clerk, etc.

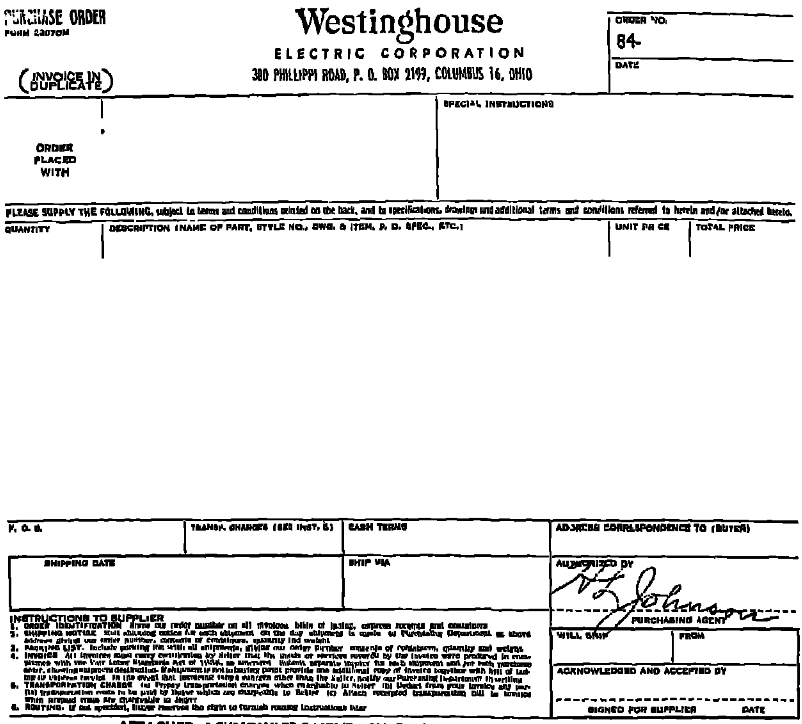
The purchase order has three principal functions: (1) it records the terms of the contract; (2) it conveys to various organization units the information that they need to carry out their part in the purchase routine; and (3) it serves as a control instrument for the purchasing department. The purchase order in Fig. 20.4 shows the type of information which is required. The general conditions and instructions which are frequently printed on the back of the original or vendor's copy should be referred to specifically on the face of it so that they will thus be incorporated in the contract. Any separate specifications should be stapled to this copy and similarly incorporated. From this point we shall be concerned largely with the vendor's completion of the contract and the closure of the purchase.

Traffic and Transportation

The traffic department in Fig. 19.1 is shown as a separate department within the supply division. There are a number of reasons for this. Traffic

must serve the marketing function as well as purchasing. Transportation charges are a major cost factor in some industries. A substantial proportion of our inventories of both raw materials and finished products may be in transit.

Traffic and transportation may be a major function in some industries. It breaks down in the petroleum industry, for example, into major divisions for transportation by rail, water, and pipe line.


PURCHASE ORDER
FORM 5207CM
(INVOICE IN DUPLICATE)

Westinghouse
ELECTRIC CORPORATION
380 PHILLIPPI ROAD, P. O. BOX 2199, COLUMBUS 16, OHIO

ORDER NO. 84-
DATE

ORDER PLACED WITH

SPECIAL INSTRUCTIONS

PLEASE SUPPLY THE FOLLOWING, subject to terms and conditions printed on the back, and to specifications, drawings and additional terms and conditions referred to herein and/or attached hereto.

QUANTITY	DESCRIPTION (NAME OF PART, STYLE NO., DWG. & ITEM, P. D. SPEC., ETC.)	UNIT PR CE	TOTAL PRICE

F. O. B. | TRANSP. CHARGES (SEE INST. 6) | CASH TERMS | ADDRESS CORRESPONDENCE TO (BUYER)

SHIPPING DATE | SHIP VIA | AUTHORIZED BY

PURCHASING AGENT

WILL SHIP | FROM

ACKNOWLEDGED AND ACCEPTED BY

SIGNED FOR SUPPLIER | DATE

INSTRUCTIONS TO SUPPLIER
1. ORDER IDENTIFICATION
2. SHIPPING NOTICE
3. PACKING LIST
4. INVOICE
5. TRANSPORTATION CHARGE
6. ROUTING

ATTACHED ACKNOWLEDGMENT MUST BE SIGNED AND RETURNED PROMPTLY

Fig. 20.4. A Purchase Order, Original Copy. (Courtesy, Westinghouse Electric Corporation.)

This function is usually associated with the supply division in a manufacturing organization. The bulk of its work has to do with such activities as classification of materials and product for traffic purposes, the routing of shipments, the provision of cars or trucks by a common carrier, and similar problems. In the case of the routine purchase order that has been discussed, it might expedite the shipment subsequently, if it were delayed in transit from the vendor's plant.

Purchase Follow-up

The control of purchasing is concerned with regulating and coördinating procurement activities in a manner which will assure their effective and economical performance. Its internal phases are concerned with coördinating purchasing activities within the organization. Its external phases are concerned primarily with making certain that the vendor carries out his part of the contract in accordance with its terms. It should assure also the delivery of the shipment promptly by the carrier in good condition. Hence this coördination involves such functions as follow-up, traffic, receiving, receiving inspection, and invoice checking.

Follow-up is that phase of purchase control which is concerned with the proper execution of the contract with regard to delivery. Its objective is to assure delivery of the shipment when and where specified. It must follow the progress of the purchase order from the time it is released to the vendor until the shipment is received. Follow-up also makes certain that any interference with prompt delivery is removed as quickly as possible. This involves the comparison of the vendor's and carrier's progress in making delivery. It may require the coördination of their functions with those phases of buying and traffic that have to do with expediting delivery. For these reasons, all papers relating to the execution of the order by the vendor and the carrier should go through the follow-up clerk's hands.

The nature and scope of the follow-up procedure vary between concerns. As a rule, a copy of the purchase order is forwarded to the follow-up unit of the purchasing department. This copy is filed by purchase order number when a tickler file card has been made for it. The card is filed against the date when the first follow-up should be made. At this time, a form letter may be sent to the vendor requesting confirmation of the shipping date, if he is doubtful of being able to meet this date. The matter will probably be turned over to the buyer who negotiated the purchase, if it is doubtful that the vendor will deliver on the promised date. The buyer is responsible for the successful consummation of the purchase, taking whatever steps may be necessary to expedite action on the order. The nature of the follow-up contacts varies with the importance and urgency of the order. In some cases none will be necessary; for others a form letter, personal letter, special delivery, telephone, or telegraph will be used; in a serious emergency, a representative of the purchasing department may be sent to the vendor's plant. The

subsequent phases of the follow-up work will become apparent as the discussion of the purchase procedure continues.

The Completion of the Contract

The vendor sends an invoice and a bill of lading to the purchasing department when the order has been filled and the goods delivered to the railroad. These instruments go through the follow-up section of the receiving department. The invoice should be dated as of the day of shipment. Consequently, the follow-up clerk will know when the shipment left the vendor's plant, and approximately when it should be received. If it does not arrive, he may ask the traffic department to trace it; in some instances a traffic representative may be sent out to expedite its movement.

The invoice is a written notice to the effect that the vendor has rendered certain goods or services in accordance with the terms of the contract, and demands payment therefor. It is also his statement of the amount and kind of the goods or services rendered, and the terms of the purchase contract. The vendor is usually requested to send in his invoice in duplicate, the original priced and the duplicate not priced. The original goes to the invoice clerk, and the duplicate to the receiving department.

When the invoice clerk receives it, he attaches an invoice flag to it, or rubber-stamps a form on the back of the invoice. This provides a record of the action taken on each invoice. The invoice is checked against the purchase order to determine its correctness, and the results are noted on the flag. Similarly, when the receiving department's report is received, it also is checked against the purchase order and the invoice. Still other entries may be made, but these indicate sufficiently the nature of the invoice-checking function. Since it is concerned with comparing the vendor's actual performance, on the basis of price, quantity, and quality, with the predetermined performance specified by the purchase order, it is obviously a purchase control function.

The discount date is an important entry on the invoice flag. A reputation for discounting bills has a most favorable effect on a firm's credit standing. Furthermore, a discount of 2 percent payment within 10 days is at the rate of 36 percent per annum. For these reasons, most concerns will borrow money from their banks in order to discount their bills. Therefore the invoice clerk must watch the discount date for each bill to make sure that the right to discount is not lost because of a delay in receiving and inspecting the goods or in approving the invoice for payment. In fact, when dealing with a trusted vendor, a company often pays its bills and takes the discounts before the goods are inspected.

The bill of lading is the receipt which the railroad or other carrier gives the vendor for the goods that he has turned over to it for shipment. It is made out by the vendor and signed by the freight agent. One copy goes to the vendee; the second goes to the carrier and accompanies the shipment of goods, and the third is retained by the vendor.

The vendee's copy is received by the purchasing department with the invoice and is turned over to the receiving department. When the shipment is delivered, the receiving department turns its copy over to the carrier and receives the goods. In a large concern with a highly developed traffic department, this copy may be sent to the yardmaster's office. The yard crew receives cars from the carrier, and moves them to the receiving dock of the proper receiving department. In such a concern, each of the larger plants may have its own receiving department. A bill of lading is not required for goods shipped by express, but instruments serving similar purposes are used.

In discussing the economics of business procedure, it was pointed out that adequate provision should be made for closing each major phase of a project, as well as the completed project. Otherwise proper coördination may be difficult. The various organization groups concerned in the project may not receive promptly the information needed to perform their functions properly. The final closing of a purchase project affects, in addition to the purchasing department, the accounting department, which must account for the transaction, and the treasurer's department, which is the custodian of the company's funds.

When the shipment is delivered, the receiving department checks it as to kind, quantity, and condition. It makes out a receiving report, sometimes called a materials received sheet, which is checked against the invoice and its own copy of the purchase order. If the material has been bought on the basis of specifications, it must be inspected, in which case either the shipment is moved to the receiving inspection department or samples are sent to the laboratory. In any event, a receiving inspection report should be originated. When the shipment has been received, checked, and inspected, it is forwarded to stores with a copy of the receiving report. This copy may be sent on to the stores record section when the goods have been stowed. The various receiving papers are forwarded through the follow-up section to the invoice clerk in the purchasing department. The instrument that finally closes out the purchase project is the receiving department's copy of the purchase order. As it goes to the various groups participating in the purchase routine, it serves

as a notice to close out their records. The invoice may cover only a partial shipment. It can only close out that shipment.

In the purchasing department, the invoice is checked and certified for payment. It is forwarded to the accounting department together with any necessary receiving papers. Copies of the various purchase papers are sent to the records section. The project is closed out as far as the purchasing department is concerned, unless certain adjustments on the invoice have to be taken up with the vendor.

The accounting department will probably post the transaction to a voucher register. As a rule, the entry is the basis for a credit to accounts payable in the general ledger, and a debit to the materials controlling account for the particular commodity. A voucher covering the transaction is usually forwarded to the treasurer's office, which may write a remittance letter covering the invoice. This is merely a check with sufficient carbon copies to serve accounting and financial control purposes. The original copy goes to the vendor in payment of the invoice. A duplicate will probably be returned to the accounting department. This duplicate is usually the basis for a debit to accounts payable in the general ledger, and a credit to cash. This closes out the transaction, as far as the company is concerned.

The Purchase of Unclassified Materials

The above discussion has been presented with particular regard to the routine purchase of classified items. Unclassified materials are handled in much the same way. A department head cannot get such material on an ordinary stores requisition. He usually has to originate a special purchase requisition which requires approval by an authorized superior. All such requisitions above a specified amount must as a rule be brought to the attention of the purchasing agent. Whenever possible, the purchasing department tries to substitute classified for unclassified items. One reason for classifying materials is to integrate the company's purchasing power. The use of unclassified items, except when necessary in special cases, tends to defeat this purpose.

Purchasing for Continuous Manufacturing

Large concerns engaged in continuous manufacturing usually buy their prime materials in great volume. In consequence, purchase functions may be differentiated to a much greater extent than was discussed above. The principal chain of command of the purchasing department results from the devolution of the buying function. In a large corporation which

has a number of independent operating divisions, this chain may consist of a general purchasing agent, purchasing agents located in the various operating divisions, assistant purchasing agents, buyers, assistant buyers, and various clerks. There probably will be a central purchasing committee. Its function is usually to get a meeting of minds concerning common divisional materials requirements that should be bought centrally under corporate contracts. The intent is a more effective integration of the corporation's purchasing power. The traffic function will be completely differentiated within the supply division. In the purchasing department of each manufacturing division the buyers may be specialized by plants as well as by commodity.

The principal changes in the purchase procedure have to do with buying direct materials. Blanket contracts are used to a greater extent. A large demand coupled with high turnover may make it necessary for the corporation to cover its materials requirements for the coming period considerably in advance. The authority to ship materials under this contract is probably released by means of a purchase delivery schedule based on the production program. This represents the application of the flow control principle to purchasing. It has been pointed out previously that for continuous manufacturing there must be a continuous flow of materials into the plant, which is coördinated with the requirements of the production schedules. These in turn must be related to the anticipated sales demand during the coming period. The method of developing a delivery schedule with regard to this coördination may be merely an extension of the method for formulating a production schedule in continuous manufacturing. For example, Operating Division N produces Models A, B, and C of the product. The cumulative daily production schedule for the coming period is as shown in Fig. 17.3. A certain grade of steel is used for various parts in all three models. The division wishes to make a delivery schedule for this steel to cover plant production requirements for the week ending February 3. To simplify the problem, assume that plant K makes all machined parts using this steel. Each unit of Model A requires approximately 20.685 pounds of the steel. Its component parts for which this steel is used have a stores and factory float of approximately 7 days. Plant K has a 10 day lead on the end of the assembly line. In other words, any steel of this kind for Model A that is delivered up to and including January 26 is to cover the scheduled parts shipments from plant K up to and including February 3. These shipments should meet the model's final assembly requirements as of February 17. The program for Model A as shown in Fig. 17.3 calls for a cumulative total

of 35,500 units for shipment on the latter date. Inasmuch as each unit requires 20.685 pounds of this steel, the cumulative total delivery requirements for the particular steel up to and including January 26 are approximately 734,318 pounds, or 367 tons. Applying this procedure to other models and summarizing total cumulative requirements for all its models, the division can quickly and easily make a schedule of deliveries to plant K's receiving dock to cover production requirements for the week ending February 3, and for subsequent weeks if it desires. The schedule for this and other steel items will be submitted to the particular company that supplies this material. Such schedules should be worked out by the production control department of Division N and transmitted to its purchasing department for execution. The production control department is usually the principal coördinative staff agency of the manufacturing division. The computing work may be done by an office service department that has machine tabulating and computing equipment.

Some of the complexities of the purchasing agent's problems, as for example, his great responsibility in connection with the expenditure of large sums of money have been examined. Today he is often a major technical staff executive. It is impossible to consider all of his problems in a general discussion. Attempt has been made merely to state the general objectives of the purchasing department; to examine the principal functions and factors that enter into purchasing; to relate them through certain organizational and procedural principles; and to examine a few of its problems. The cumulative effect of the department's contributions, over a period of time, should be a reasonable achievement of the general objectives noted at the beginning of this discussion: an adequate supply of the right kind and quality of purchased materials which will be available when and where needed, and for which will be paid the lowest unit price consistent with requirements.

PROBLEMS

1. The assistant plant manager in Fig. 15.5 has complained about a certain item of direct materials. This item is being bought on the basis of specifications that have been supplied by the engineering division. The assistant manager alleges that the factory is unable to maintain the production schedules for the parts that use this material. He states that there are excessive rejections by inspectors when operations on the parts are run at the feeds and speeds that have been specified by industrial engineering. It is felt that it is unnecessarily difficult to machine the specified material economically. The chief engineer maintains that the specifications are correct and necessary. Any similar material that has the specified quality attributes, plus greater "machinability," will cost substantially more per pound. The plant accountant

will be unhappy about an increase in the unit cost of the parts affected. The company's comptroller has been putting on the pressure for a reduction of both direct and indirect costs. The company set up a purchase planning and research department in the supply division about six months ago.

(a) What technical staff group should be given the responsibility for staff leadership in the solution of this problem? Why? What would be your general approach to the solution of a problem of this kind?

(b) The initiative in cost reduction or quality improvement for purchased materials may originate with the purchase planning and research group. What general procedure for the initiation and conduct of a materials cost reduction study would you set up? Would you staff the P. & R. group with the necessary engineering, production, and accounting personnel, or would you make use of such personnel in other technical staff and line organizations of the plant? Why?

2. The company's research laboratory has developed a special material that is peculiarly well adapted to the needs of the product. The company has no facilities for making this material, nor does the management believe that it would be profitable to manufacture it. Several concerns have the necessary equipment for producing this material to the desired specifications. The question has arisen as to whether the purchasing department should order from only one of these companies, or from more than one. The management of course wants to pay as little as possible for the material.

   (a) What considerations should be taken into account in deciding this?

3. The company is an independent division of a large manufacturing corporation. In answer to requests for quotations on a certain purchased part, to meet definite specifications, the purchasing department receives a quotation from another subsidiary of the corporation. While it is the second lowest bidder, its price is above the low bid by an appreciable percentage.

   (a) As the division purchasing agent, what policy would you follow in handling this situation? Why? How would you proceed?

4. The company manufactures a durable consumers' good. About 60% of its dollar volume of business has resulted from installment sales by its dealers. There has been substantial decline recently in the amount of installment sales by the particular industry. The percentage decline in the company's sales has been approximately the same as that for the industry. Sales forecasts indicate that the decline in sales may be expected to continue for some months. The company's plant is organized for the straight-line continuous production of its products. The executive committee has recommended that inventories be kept in line with declining sales and production. The supply division manager wishes, accordingly, to cut back deliveries of direct materials by its vendors. What is required to enable the purchasing department to do this? How should it proceed?

CHAPTER 21 •

• The Stores and Salvage Functions of Supply

The Stores Department

THE purchasing department is concerned chiefly with securing materials and supplies by purchase. As a rule, its responsibilities end with the delivery of the material, provided it arrives in good condition and meets specifications. At this point, responsibility for the materials usually passes to the stores department of the supply division, where it remains until the goods are issued on proper authority. It becomes the physical custodian of all inventories not charged directly to some department or order. It is responsible for the safety of this material until it is issued. Inasmuch as inventory values may run into large sums of money, the importance of the stores function is readily apparent.

The principal phases of the stores function are: (1) receiving materials, (2) stowing and issuing them, (3) providing internal transportation, and (4) shipping the finished product. In a large concern, each of these phases may be represented by a department. The stores organization will probably then be under a stores superintendent. He reports, in Fig. 19.1, to the supply manager. The stores department provides chiefly a technical staff service of facilitation in the supply of materials.

The Receiving Section

The receiving section is concerned with the proper induction of materials into the plant; hence all purchased material should pass through it. The section must see that such goods are inspected by receiving inspection, or the laboratory, to determine whether they conform to the specifications in the purchase contract. Inspection may not be necessary for all purchases, however. Receiving must make reports on the condition of each shipment, and the kind and quantity of material received on each purchase order, and send copies of these reports to every department concerned.

The principal phases of the receiving function are: (1) unloading the

shipment, (2) unpacking and loading the material into proper containers, and (3) checking and recording the shipment. Freight shipments can be used to illustrate these phases. There are some significant differences in the handling of truck and freight shipments, however.

A large factory which is composed of many plants often has extensive yard trackage and a yardmaster. He usually reports to the traffic manager and is responsible for internal freight traffic. He sees that the cars delivered to the plant's siding by the carrier are moved to the receiving dock of the plant that is to receive the shipment. The head of the receiving section is usually known as the receiving clerk. In a large department he is usually assisted by a car checker, who is in charge of the unloading crew. As his crew unloads the car, he checks the shipment on a car report. The checker records such information as the carrier's name, the car number and other identifying marks, the condition of the seals on the car, the number of each kind of boxes, bales, crates, etc., their marks, any damage, etc. This report is needed by the traffic department for checking freight bills, and for making any damage claims. The various materials may be moved to the receiving floor by means of hand trucks, portable screw conveyors for bags and bales, floor-level slat or platform conveyors, or almost any of the materials-handling equipment discussed in Chapter 11. Thus in Fig. 11.4, malt is being unloaded from a barge with a pneumatic conveyor; a combination of a gravity-roll conveyor and a push-bar elevator is used in Fig. 21.1 for receiving materials.

In addition to the car checker, the receiving clerk may have a receiving foreman who is in charge of the receiving floor. His force may be divided into several floor crews, each supervised by a floor checker. As the various containers come on to the receiving floor, they are moved to a floor crew for unpacking. As the material is unpacked, it should be loaded into standard containers in standard quantities to facilitate its stowage and control in the storeroom. The floor checker records on a floor report the case numbers or other marks, the count of each kind of material, etc. The count for each case may be checked against a packing slip. This is the vendor's record of what went into the case; the slip may be enclosed with the material, or forwarded through the purchasing department to the receiving section of the stores department. If the two counts do not agree, a recheck is, of course, made at once. The floor report is turned in to the receiving department office, and the material is moved to stores, to the receiving inspection department, or, in the case of unclassified stores, to the department for which it was purchased.

The receiving department office checks the floor reports against the

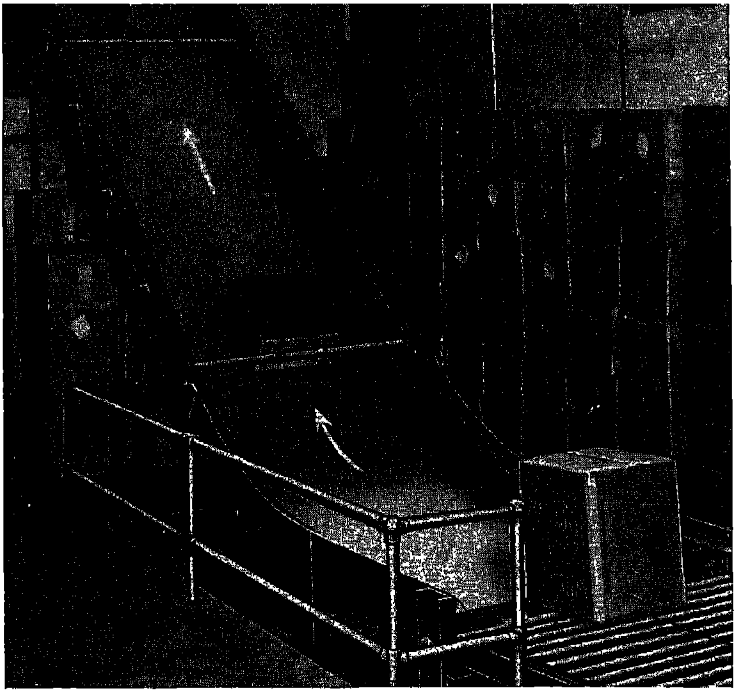


Fig. 21.1. A Combination of Gravity-Roll Conveyor and Push-Bar Elevator, Used in Receiving Materials. (Courtesy, The Logan Co.)

department's copies of the car report, the invoice, and the receiving copy of the purchase order. The receipt of the shipment is recorded on a receiving report. This is merely a form on which the receiving section records the pertinent facts concerning the receipt of a shipment under the authority of a purchase order. It reports such information as the purchase order number, the vendor's name and address, the date received, the carrier, packing slip and floor report numbers, the quantity received on the shipment, any shortages, the quantity rejected by inspection, the specification number or other description of the material. The receiving department may report any other information that is necessary to close out the shipment, or handle it subsequently.

The materials will be sent to their immediate destination, the storeroom, warehouse, or requisitioner, accompanied by a copy of the receiving report. The materials will be sent through the receiving inspection section of the inspection department, or to the laboratory, when the quality of the goods must be checked. A copy of the inspection report, together with the rejected material, will be returned to the receiving section, to enable it to complete its records. Copies of the report will probably be sent then to the purchasing department. The receiving section's copy of the invoice for the shipment should be sent with the report. This closes out

the shipment. The receiving report and invoice do not necessarily close out the purchase order, because the particular shipment may be only a partial delivery.

The head of the receiving section is the receiving clerk. He is not a clerk, but a minor executive, in a concern of any size. He is responsible for the safety of all materials from the time of delivery by the carrier until turned over to the storeroom or the requisitioner for whom intended. When material is rejected for failure to conform to specifications, ordinary care must be taken to protect it from damage or theft, for otherwise the company may be held liable for its value. Unless shipments are unloaded promptly and the cars released to the carrier, the company may have to pay demurrage charges. These and other responsibilities of the receiving clerk make it necessary for him to have some ability to plan, organize, and control the work of his department.

Some concerns put the receiving department under the purchasing department on the theory that receiving may be regarded as one of the final steps in the purchasing routine. However, it is also the first step in putting materials in stores. Furthermore, the receiving department is concerned primarily with the physical rather than the clerical handling of materials; its work is both complementary and similar to that of the storeroom. For these reasons, it has been placed under the stores department.

Receiving Inspection

The average receiving section is not equipped nor is its personnel trained to make more than an ordinary visual inspection of goods for obvious damage in transit. When a technical comparison of goods with specifications is necessary in the small plant, it is made by an inspector or the executive who will use the material. Large concerns usually have a receiving inspection section under the chief inspector for this purpose. If a laboratory test must be made, as in the case of coal or steel, the receiving department usually holds the shipment while samples are being tested in the company's laboratory. A receiving inspection report should be originated to enable the purchasing department to adjust the invoice for any rejections. Every shipment is not always inspected, however, even when it has to conform to specifications. If the material is giving satisfactory performance, no inspection whatever may be made. In other cases, samples of it may be inspected. If it starts to cause trouble, all future shipments may be subject to complete inspection until the difficulty is corrected.

The Storeroom

The storeroom is responsible for the safety, care, and disbursement of all materials and supplies not in process or in use. It is supervised by a storekeeper, under whom are a number of store clerks and laborers. Large factories may have several storerooms and warehouses, located in different plants. In such cases, the various storekeepers will probably report to a general storekeeper, who in turn reports to the stores superintendent.

STOREROOM LAYOUT AND EQUIPMENT

Materials may move in and out of the storeroom almost continuously and in large quantities. In consequence, the storeroom layout is important in handling them. To facilitate quick deliveries and shorten the distances over which it must be moved, each item carried regularly in stores should be stored as near as possible to the department that uses it most frequently and in the largest quantities. However, this practice may have to be modified because of the characteristics of the materials as they affect stowage and materials handling. Substorerooms are often located near the departments that use particular items constantly and in large quantities. Thus the copper and spelter used in making brass in a munitions plant would be stored in a substoreroom in or near the brass foundry rather than in the general storeroom. The quantity, rate of use, and also the character of the material affects its location in stores. For example, coal is usually piled in yards near the power plant, whereas the high explosives used in making cartridges are stored underground at some distance from the plant to reduce the danger of disastrous explosions. Yard storage is shown in Fig. 21.2. The relation between the amount of storage space available and the quantity and bulk of the material will also affect its location. The type of conveying equipment may be a factor. There are still others that affect economy in storing materials.

In laying out the storeroom, the main aisles should run in the general direction of the flow of material into the plant in order to minimize congestion. These aisles should be wide nough—as a rule at least 10 feet—to permit trucks to move freely in and out. The side aisles leading from the main aisles should be wide enough to allow two trucks to pass each other. The distance between the bin stacks should be wide enough for a man and a truck.

Bins for storing material are made of wood or steel. In modern storeroom installations, knock-down, sheet-steel bins similar to those in Fig.

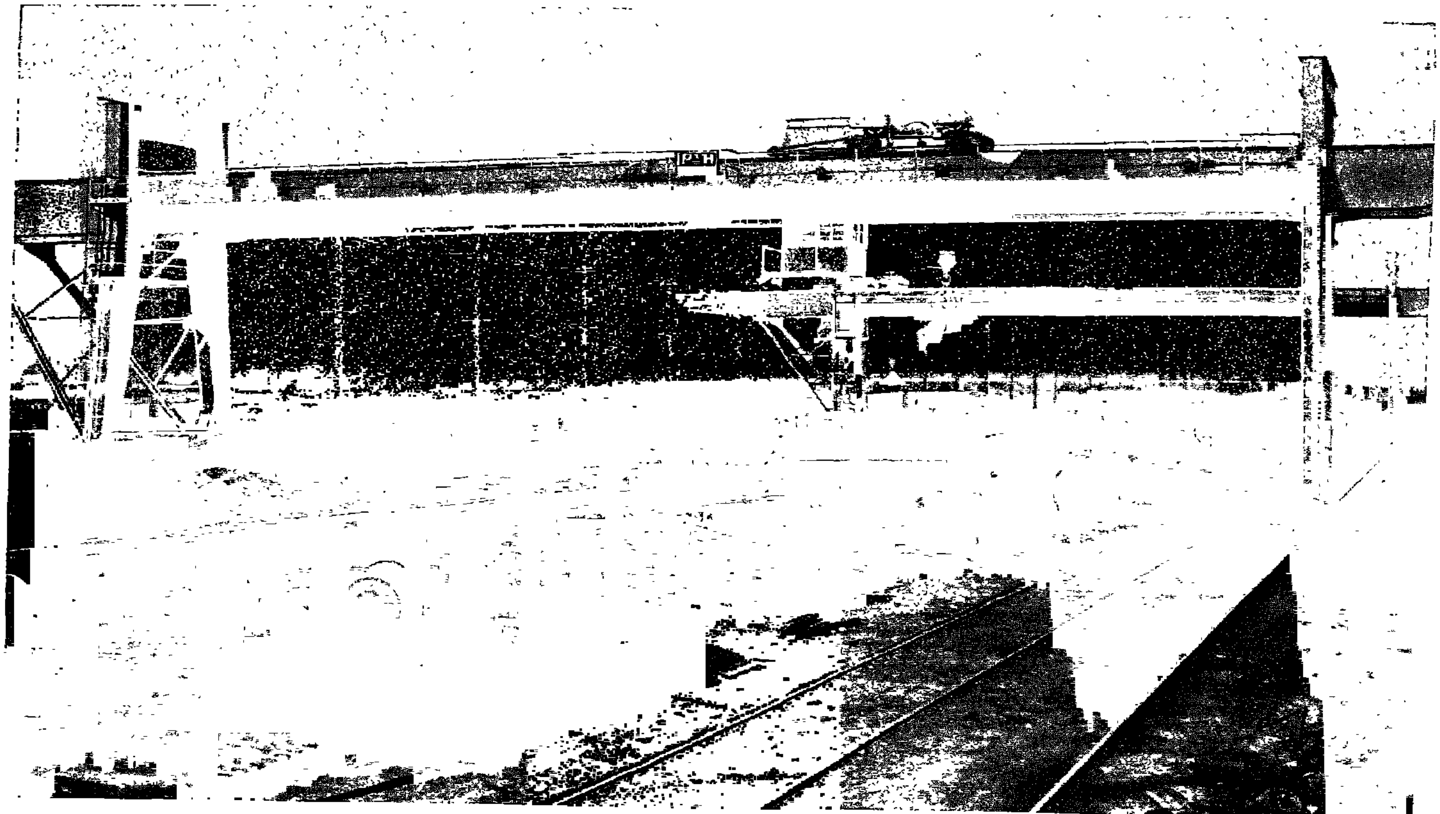


Fig. 21.2. Gantry Cranes Used in a Storage Yard. (Courtesy, The Harnischfeger Co.)

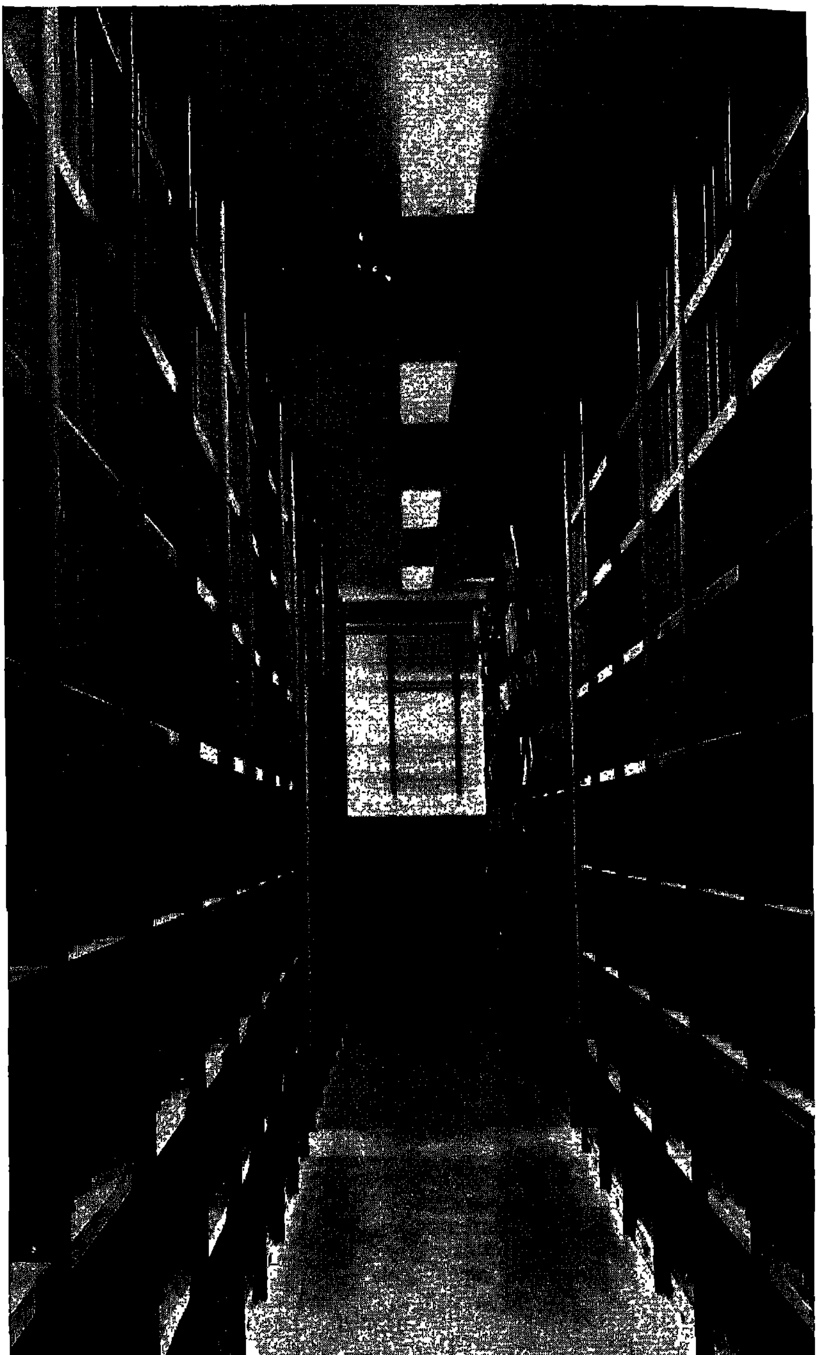


Fig. 21.3 Sheet Metal Bins for Stowing Materials. (Courtesy, The Berger Div., Republic Steel Co.)

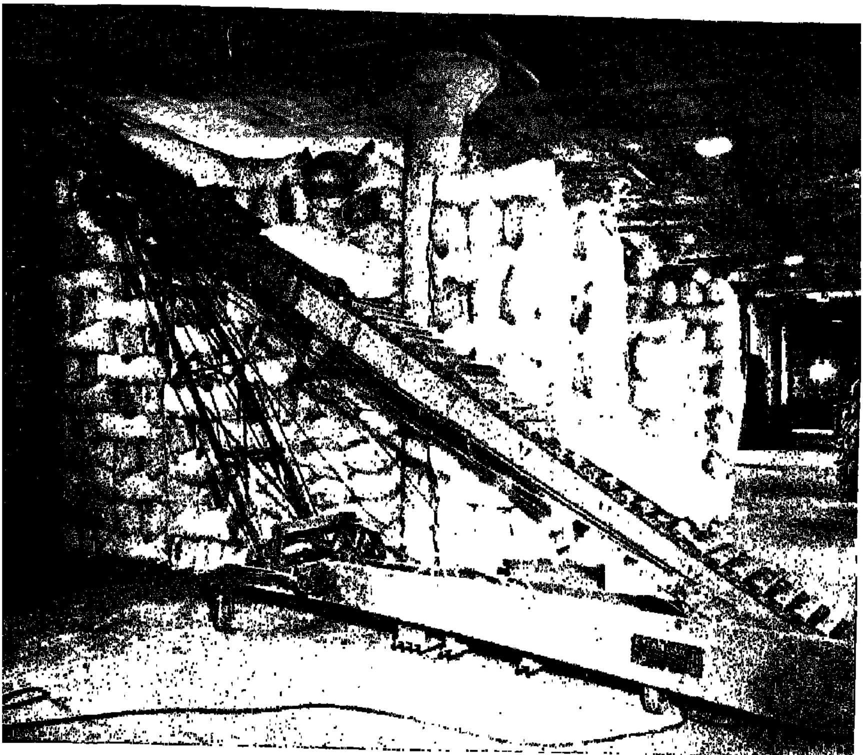


Fig. 21.4. Sacked Material, Piled with the Aid of a Portable Power-Driven Slat Conveyor. (Courtesy, The Standard Conveyor Co.)

21.3 are used, thus providing greater flexibility in the sizes of bins. This is an advantage when the layout of the storeroom has to be changed to conform to changing business volume and materials requirements. The standard sheet-steel bin has a depth of 2 feet. It is so constructed that it can be assembled in varying heights and widths depending on the materials to be stored. As far as possible, bin sizes should be standardized to facilitate the shifting of stocks when necessary. The determination of standard sizes may be affected by the units in which the items are issued.

After the storeroom has been laid out, symbols should be provided for the various bins and storage spaces so that materials can be located easily and quickly. Starting with those nearest the entrance, for example, the bins and storage spaces may be numbered in sequence according to their location in the storeroom. In addition, each section of a stack is lettered in alphabetical sequence, and each tier is numbered; thus the symbol 25A5 on a requisition may indicate that the bin for the material is in stack 25, section A, tier 5.

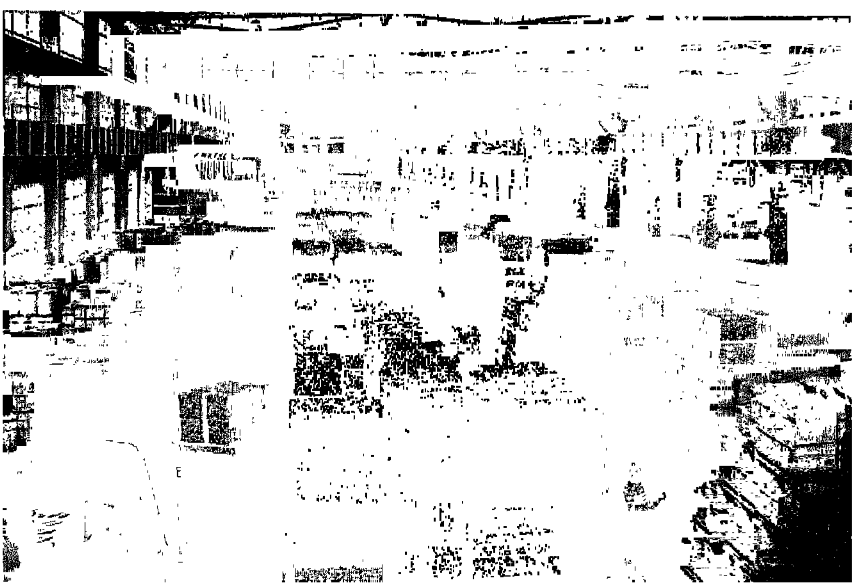
Some materials must be piled in open storage spaces. Some examples are lumber, various kinds of pig metal, sacks of loose material like those in Fig. 21.4 and barreled materials such as are shown in Figs. 21.5 and 21.6.

The size of the storage space will be affected by the nature and quantity of the material to be piled. The dimension of this space should be standardized as far as possible. For example, the size of tote boxes for transporting material should be standardized so that a certain number of a given size can be piled on the platform of a lift truck. Open storage spaces should be marked off by lines painted on the floor, so that a certain number of lift-truck platforms can be stored in each space. These storage spaces or bays should also be given symbols. Signs may be hung from the storeroom ceiling to facilitate greater ease in locating a particular space.

STOWING MATERIALS

Even the stowing of materials is not left to the decision of a stores clerk. There are certain operative principles that underlie good storeroom practice anywhere. They should be followed if stowing is to be economical and effective. To illustrate, piling bulk material is facilitated by starting at the back left-hand corner of the storage space. As a rule, such material should be piled in multiples of 5 units for convenience in taking a physical inventory and in exercising a visual control of stock. New material should be piled behind or below the old stock so that the latter can be used first. This may be necessary with some materials to prevent loss from deterioration. Materials may be packaged in units of issue before they are stowed. It is not usually economical, for example, to issue one or two screws at a time. The packages should be wrapped securely and clearly labeled so

Fig. 21.5. An Industrial Warehouse, Showing the Use of the Pallet System. (Courtesy, The Bethlehem Steel Co.)



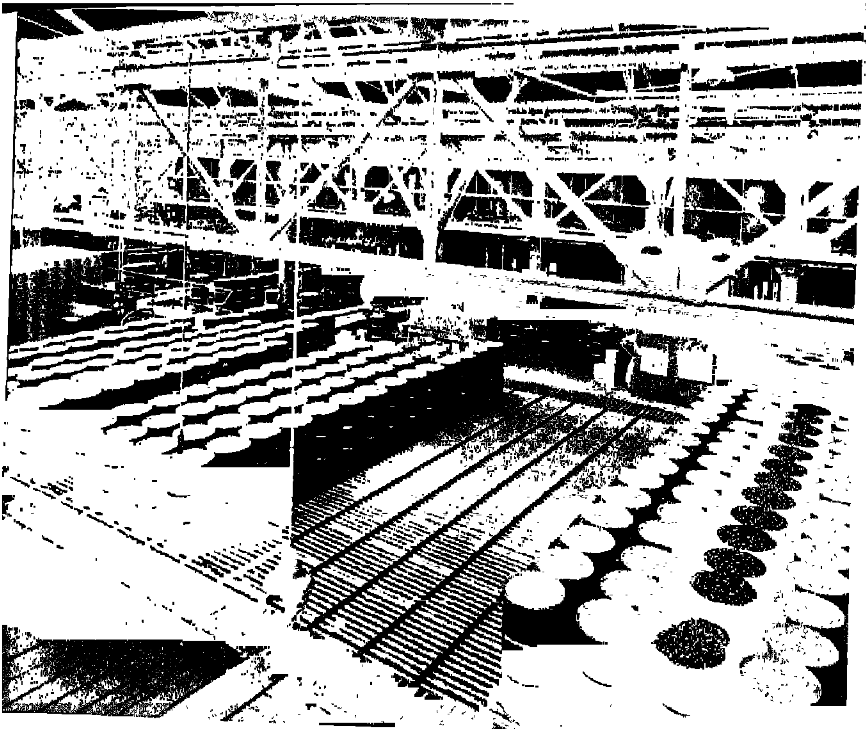
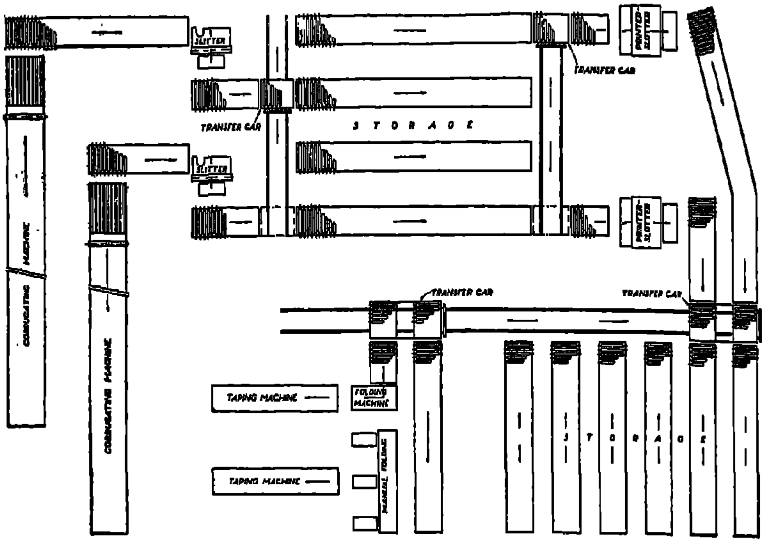


Fig. 21.6. Oil Drums Stored on Gravity-Roll Conveyors Leading to Live-Roll Conveyors. (Courtesy, The Standard Conveyor Co.)

that the kind and quantity of material in each package may be easily identified. Most plants have too little storage space rather than too much. Congestion, confusion, and loss are bound to occur unless there is a place for everything and everything is in its place. The mark of a well-managed storeroom, such as that shown in Fig. 21.5, is order and neatness.

Economy of time and effort requires that there be a minimum rehandling of material. As far as possible, material should move continuously from the receiving department to and through production without being removed from the device in which it is conveyed. For example, standard quantities of small purchased parts are often loaded by the receiving department into standard tote boxes. The stores department may stow these boxes in racks, putting a standard number of boxes in each section, and deliver them to production in the same boxes, when needed. This eliminates rehandling and facilitates a visual control of stock. Figures 21.5 and 21.11 show the pallet system of moving and stowing, another means of eliminating rehandling. Packaged bulk materials are piled on these pallets. They can be transported easily and stacked to any safe height. Rehandling is eliminated in the storage of the oil drums in Fig. 21.6, by the use of a combination of gravity- and live-roll conveyors.



Conveyors which provide adequate storage space, in addition to serving as a transportation medium, are referred to as "Live Storage." Such conveyors usually produce marked economies. Container plants are peculiarly well adapted to the live storage principle.

Fig. 21.7. The Reduction of Rehandling of Worked Material by Use of Roll Conveyors in Live Storage. (Courtesy, The Logan Co.)

Fig. 21.8. An Example of Flexibility and Capacity in Stowing Materials in a Warehouse. (Courtesy, The Lamson Corp.)

Fig. 21.9. An Example of Flexible Stowage Capacity: Nesting Tote Boxes Being Handled by a Power-Driven High-Lift Truck. (Courtesy, Elwell Parker Electric Co.)

Stops at the head of each section prevent the drums from moving on to the live-roll conveyor. The number that are moved out when this stop is released can be controlled. The live-roll conveyor will carry them automatically to any destination along its length. The layout diagram in Fig. 21.7 applies the same principle to the storage of worked material.

The equipment used in moving and stowing materials should have sufficient capacity to handle them continuously and swiftly with a minimum of damage. Figure 21.8 shows an interesting combination of belt conveyor, portable chute, and the pallet system, that has considerable flexibility as well as capacity. Another example of flexibility is shown in Fig. 21.9. Here the tote boxes nest on each other; any one of them may be removed and put in a new location. When only local flexibility is required, a hand-operated device such as the lift truck shown in Fig. 11.10 may be very efficient.

Factory floor space under normal conditions is likely to be at a

premium in a successful manufacturing plant. This usually means too little rather than too much storeroom space, relative to the volume of materials that must be stowed and handled. The available storage space must be used as efficiently as possible. It is quite as logical to make a layout for handling and stowing materials as it is to make a plant layout for moving and fabricating work in process. Some concerns therefore make a stores layout periodically. An example is shown in Fig. 21.10. Efficient stowage can be obtained in the case of floor storage by the overhead handling of materials. Such practive reduces congestion and releases floor space; this was shown above in Fig. 21.5. Furthermore, materials must be piled to the maximum height compatible with safety; Figs. 21.4 and 21.11 show this practice. There are, of course, many other principles of efficient stowage. Those cited should be sufficient to show the need for that specialized training and experience for work in the stores department.

Surplus Stock and Changes in Location

Surplus stock that cannot be kept in the regular bin or storage space has to be moved to a temporary location. Before it is moved, however, a surplus stock tag is made out for each lot. This tag gives such information as the name and description of the material, the material symbol, the normal location, temporary location, the quantity in the lot, etc., and is hung where this material would normally be stored.

Demands for storage space are changing constantly. A change in the engineering specifications may mean that considerably more of an item must be carried than was formerly the case. If its present storage space is not large enough to take care of the increase, a new location must be assigned. When the material is moved, a change of location notice should be posted in the old location to minimize any confusion that may result from a delay in changing the stores location symbol in the stores ledgers, etc. The notice gives such information as the name and description of the item, the material symbol, the units and quantities moved, and the old and new locations. A copy of it should be sent to the storeroom office for use in changing the visible index record, and to the balance of stores department for correcting the location records in the stores ledgers.

Protecting the Stock against Shortages

Checks have been provided in the stores ledgers to protect us against inventory shortages. It is a function of the reorder point to indicate when the available stock of a material is too low. However, a ledger clerk's failure to note that an item should be reordered will cause a shortage. A

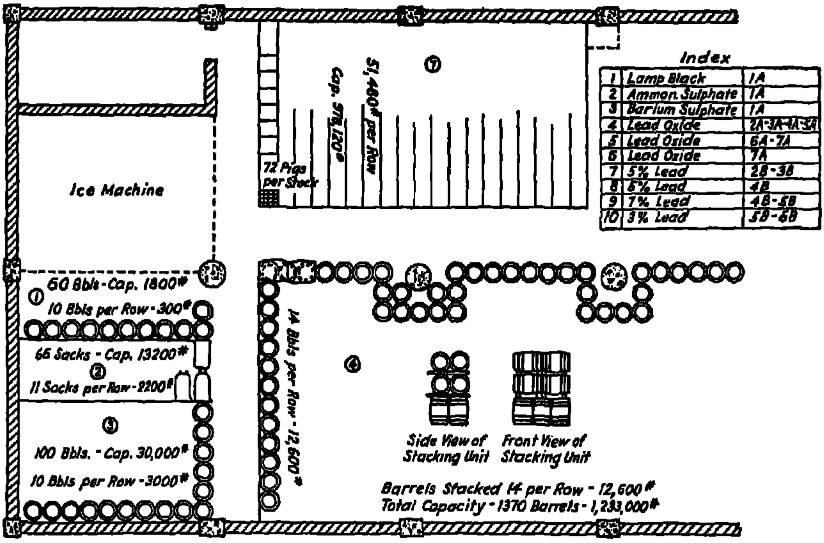
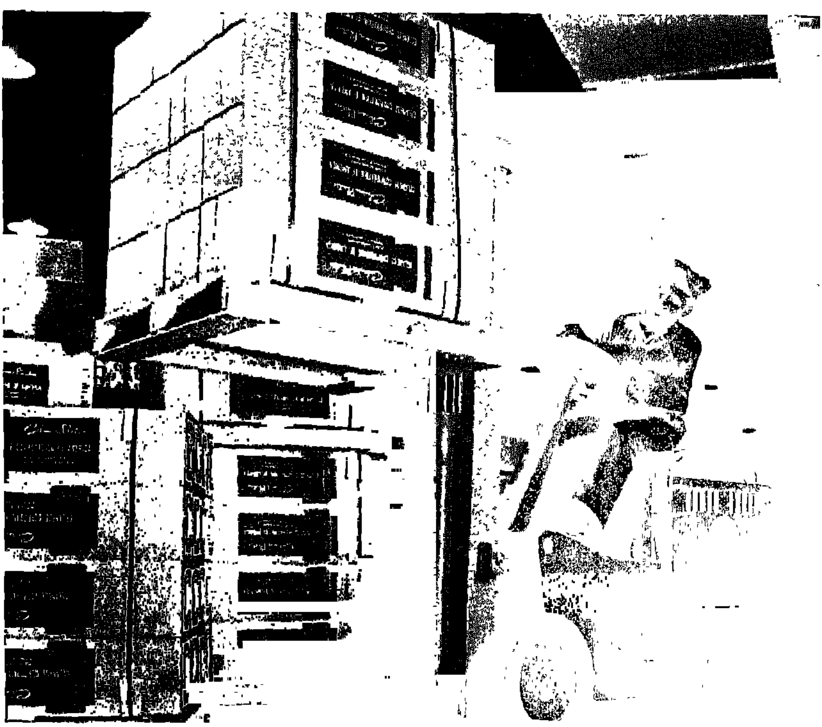


Fig. 21.10. Part of a Stores Location Diagram

Fig. 21.11. Efficient Use of Storage Space: The Elevator Truck and Pallet System of Stowing. (Courtesy, The Baker-Raulang Co.)

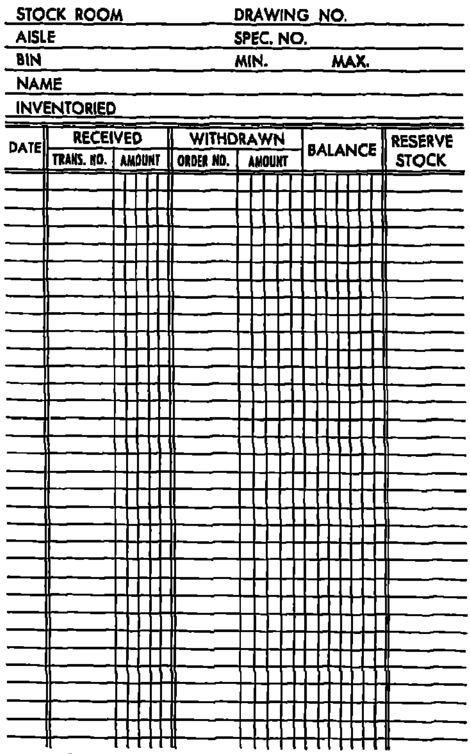


vendor may be unable to make delivery when promised. Shipments may be delayed in transit, or other contingencies may develop. For these reasons, certain checks are usually made in the storeroom also. One method involves the use of physical minimums. There are two methods that may be used: the Barth double-bin system, and the Gantt physical minimum. Under the Barth system, each item carried in stores has two bins, or whatever storage facilities are used. One bin contains the old shipment from which material is being issued; the other contains the new shipment. When the bottom of the first bin is reached, the balance of stores department is notified. It places an order for another shipment of the material. Material is now withdrawn from the second bin as needed. When the new shipment arrives, it is put in the first bin, but is not used until the second bin is emptied. With this method, dangerous depletion of the stock is avoided, and old stock is used up before the new is issued. It wastes storage space, however, and in some cases results in a larger average inventory than is necessary. The Barth double-bin system is seldom used today, for these reasons.

In the Gantt system, a certain minimum quantity is separated from the rest of the material. This quantity represents the danger point beyond which a critical shortage is imminent unless prompt action is taken to avert it. For example, if the item is a small screw and the minimum is 500 pieces, this quantity may be tied up in a sack and put at the bottom of the bin. The rest of the shipment is piled on top of it. When the bin is exhausted, the screws from the sack are dumped into it. This emergency supply is used until a new shipment is received. The empty sack is turned in to the stores office, which notifies the stores record section. The latter checks up on orders for the screw. The Gantt principle of physical minimums is applied in many forms by industries engaged in either intermittent or continuous manufacturing. It is particularly important in the latter, where it greatly influences the control of direct materials.

The stock card maintained by the stores office in some concerns is another means of checking inventories on hand. The one in Fig. 21.12 shows the type of information it usually contains. When a physical inventory of stores is taken, the amount of each item on hand is entered on a stock card. As the item is removed from the bin on requisition, the date and the amount issued are entered on the card. The amount is deducted from that previously on hand. At any time, in consequence, the card should show the quantity in the bin. Similarly, when this item is received into stores and put in the bin, the amount is added to the card. When the amount on hand drops to a specified minimum quantity, usually the

danger point, the quantity in the bin is inventoried. A new card is made out showing this quantity on hand. The same procedure is followed when the space on the card has been used up. There are several advantages of this method. The old card is sent to the stores record section to check the accuracy of the stores ledger. There is a continuous inventory of stocks of material, usually when the pieces to be counted are at a minimum.


STOCK ROOM DRAWING NO.
AISLE SPEC. NO.
BIN MIN. MAX.
NAME
INVENTORIED

DATE	RECEIVED		WITHDRAWN		BALANCE	RESERVE STOCK
	TRANS. NO.	AMOUNT	ORDER NO.	AMOUNT		

Form 520

Fig. 21.12. A Stock Card. (Courtesy, The Robbins & Meyers Co.)

Furthermore, the stock card enables the stores office to supply promptly any information concerning inventories on hand that the shop executives may need.

Some plants check the accuracy of the stores ledgers by means of a patrolling inventory. This is a continuous inventory of the stock on hand made by certain storeroom employees who do only this work. Each item of material is counted periodically, and a record of the count is sent to the stores records section. Such an inventory may be more accurate than an annual inventory, which is usually made under pressure by a temporary organization and is never absolutely accurate.

The Internal Transportation Section

In some plants there is a separate section which handles the transportation of materials in the plant. Its work is closely related to the movement of stores. This section may be placed under the stores department superintendent *in Fig.* 19.1.

The movement of work within a shop department is handled in most cases by the department's truckers. However, the internal transportation system may establish routes for the delivery of material between departments and buildings of the factory. It is responsible for the proper utilization of all transportation equipment, with the possible exception of yard engines. These engines are under the jurisdiction of the traffic department. The internal transportation section must provide for the prompt, speedy movement of materials and work, and must furnish continuous and reliable transportation service. The general nature of the section's work has been indicated previously in our discussion of materials handling.

The Shipping Section

The shipping section or department sees that the finished product is packed properly for shipment. It ships the specified quantity of the goods in accordance with the instructions of the sales department and traffic section, on the date indicated by the sales department.

The condition in which the goods are received obviously has much to do with the customer's satisfaction. Therefore the design of the container used for shipping, as well as the packing of the goods, is important. The shipping department can often save the company money by devising low-cost containers that will carry the product to its destination in good condition. Furthermore, its promptness in making shipments is important in building up customer good will.

The shipping department is usually supervised by a shipping clerk, who is a minor executive. He may have a force of clerks, loading gang bosses, laborers, carpenters, etc. The basis of the department's activities is usually the shipping order, which it receives from the sales department. On receipt of the order the department either withdraws the goods from finished stores or receives them directly from the assembly floor, depending on the nature of the company's operations. The goods are then crated and shipped as directed.

The shipping department is a part of the sales organization in some concerns. With continuous manufacturing, certain advantages in production control may make it advisable to put it under the production

organization, as a department of the final assembly plant. (See Fig. 11.8.) An examination of functional similarities appears to justify putting it under the stores organization. Like the receiving department, the shipping department is concerned largely with the physical handling of materials in the form of finished product. This phase of the problem is illustrated in Fig. 21.13 in which wire is being moved from storage in a steel-mill warehouse to gondolas for shipment.

The Salvage Department

The functions of the salvage department are collecting, reclaiming, reworking, and disposing of scrap and waste, and reducing the amount thereof. The work of the department is partly a manufacturing problem and partly a stores problem. It has to do with the reworking of scrap and waste received from the directly productive departments. The salvage department also handles the sale of scrap, waste, or reclaimed material. It returns to stores any reclaimed material which can be reissued to the shop. Scrap is product which has failed to pass inspection and which cannot be reworked in the shop to meet quality standards. Waste covers all by-products of directly or indirectly productive operations, and all materials no longer usable for their original purposes. Thus steel flashings from punch-press operations would be classified as waste.

The salvage department is often under the supervision of a salvage foreman or superintendent. His qualifications may be similar to those of a manufacturing executive more than is true for any of his fellow executives in the supply division. The salvage department is sometimes placed under the production division, for this reason. However, the department's work probably affects the supply division more than it does the production division. It is put under the supply division, consequently. The head of the salvage department must know the product and the processes in the plant, and have had exprience with salvage methods and equipment. This executive should have considerable mechanical ability because he is often forced to devise his own methods for reclaiming materials. The salvage department may have a number of distinct units, such as the salvage collection service, the sorting shop, the salvage shop, and the salvage yard gang.

All waste or scrap rejected by the inspectors should be forwarded to the sorting shop, except worked material which the operator can reprocess. It should be accompanied by a scrap tag or report indicating the nature of the item and the causes of rejection. This tag enables the proper expense or work in process account to be credited and the proper

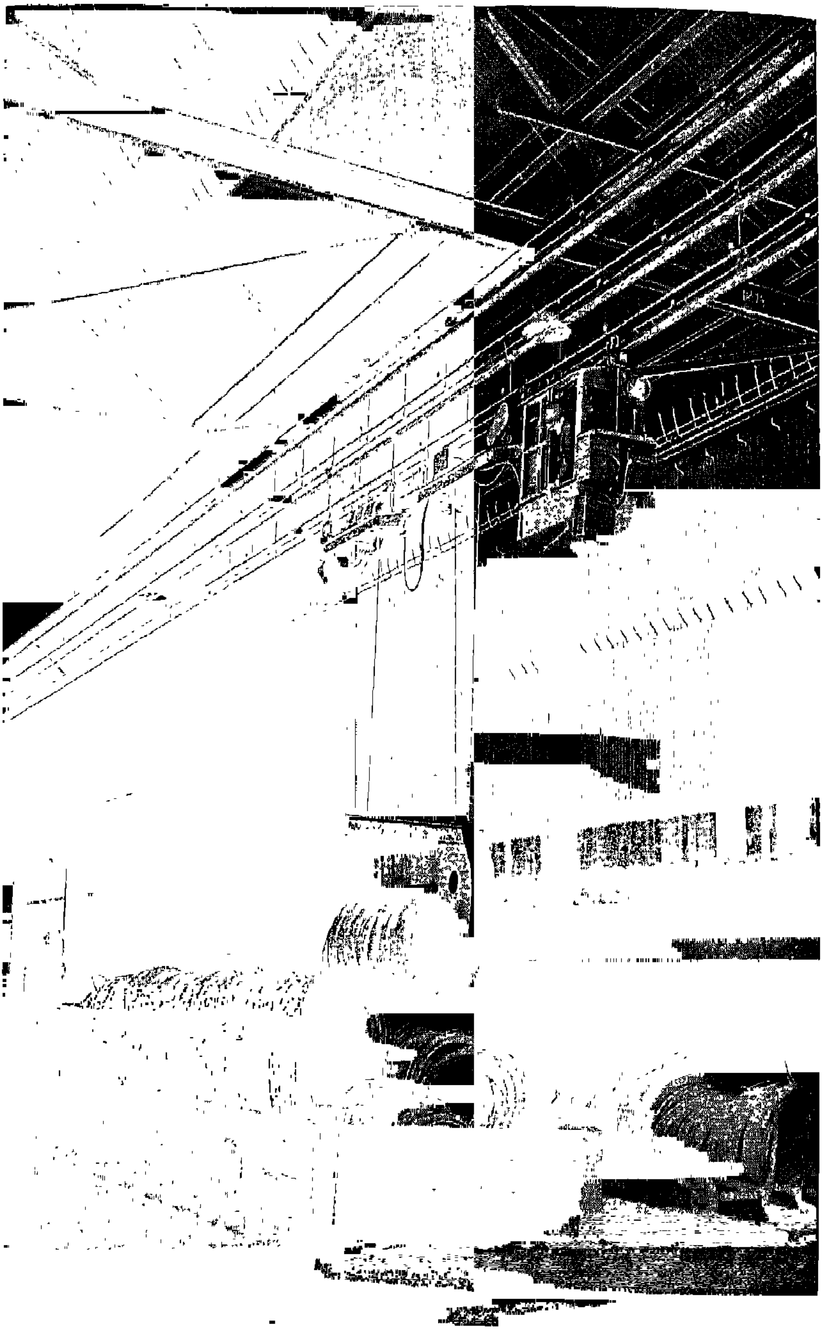


Fig. 21.13. A Monorail Telpher Moving Wire from Storage to Gondola. (Courtesy, Cleveland Crane and Engineering Co.)

salvage account to be charged. The manner in which this report is handled will depend on the nature of the salvage material and the plant's manufacturing and accounting routines. As a rule, standard containers for various kinds of scrap and waste are located conveniently in each department. These are collected regularly and taken to the salvage sorting shop. Here, the contents are sorted and classified on the basis of their ultimate disposition. Some of this material can be reclaimed and returned to stores. Part can be worked profitably for sale. Some must be sold as junk. The sorting shop should originate a report containing such information as the date of receipt, a description of the salvage material, the quantity received, the department from which it came, the disposition of the material, etc. The individual reports should be analyzed and summarized for executive planning and control purposes. One copy of this summary should be sent to the industrial engineering department, in Fig. 15.5, for the information of the process designers. Another may go to the division superintendent who is responsible for the departments producing the waste and scrap. The salvage department manager should receive a copy, of course. The sorted material is sent either to the salvage yard to be stored pending sale, or to the salvage shop to be worked.

A great variety of equipment has been developed for reclaiming or reworking scrap and waste. For example, powerful machines have been developed for pressing and baling the sheet-steel flashings, in convenient form for sale. It brings a higher price per pound, in this condition. The cost of cotton waste used for cleaning machines is sufficient, in large plants, to warrant the installation of centrifugal machines to reclaim it. Automatic screw machines and other automatic machines which use cutting oils are equipped with wells. The oil is pumped to the point of work, the cutting tool, by small pumps attached to the machine. When it becomes foul and unfit for further use, it is taken to the salvage department and reclaimed. Steel and other metal turnings are taken to this department and sorted according to kind. They are stored in the salvage yard near a railroad siding pending sale.

The varied activities of the salvage department can save the company large sums of money in the course of a year. One of its greatest fields for saving is the reduction of waste. The salvage department should study constantly the causes of waste and scrap in the plant, in coöperation with the production, process design and inspection departments. This department can do a great deal toward reducing this costly item of expense by suggestions concerning manufacturing methods, employee education and training, and other phases of the problem. Exhibits of waste and articles

in the plant magazine on waste reduction are some of the educational methods that have been used.

PROBLEMS

1. A company, originally organized on a small scale to do several specialized machining operations, gradually increased the scope of its service to include the complete fabrication and assembly of several products. As a very small firm, its stores activities were performed by production operatives, as part of their regular duties. As the organization increased in size, several operatives were assigned, full time, to the work of handling materials and supplies. A stores department was set up eventually with a full-time supervisor in charge. The average wage of employees in the stores department is $1.75 per hour. This compares with $1.90 for line production departments. The factory manager has recently questioned the wage costs of the stores department, nevertheless. There are now 14 stores employees, plus the stores supervisor. There are now 410 directly productive operatives in the production line departments. A survey of certain noncompeting companies in the metal-working industry has been made to get an answer to the manager's question. The companies surveyed were selected because of their similarity in size and manufacturing problems to the company under discussion. The survey was made at the suggestion of the factory manager. The results show that the ratio of operative employees in the storeroom to directly productive employees in the factory averages approximately 6.5% in the companies that were surveyed.
   (a) The factory manager's question implies that we have too many employees on the stores department's payroll? What is your reply to his question? Justify it.
   (b) What is the significance, if any, of the difference between the number of people that the average company would have in the storeroom, and the number that this company has?
   (c) Does it follow that we should hold to a certain line-staff ratio because this is the average ratio for other companies in our manufacturing field? Why?
   (d) Do personnel in a staff function tend to increase in the same ratio as line personnel? Is there any logical justification for the use of such ratios?
   (e) What stages of functional differentiation are evident in the above case?
2. An order of 200 pieces of Part 1850, a purchased part, is received by the receiving department. After going through the receiving routine, it is forwarded to receiving inspection, a separate section under the chief inspector. Here 20 pieces of the part are rejected.
   (a) What functions, in addition to inspection, are affected by this procedure? Why?
   (b) What information concerning rejections do the departments responsible for these functions need if they are to carry out properly their particular part in the purchase procedure? Suggest a procedure that will insure that they will receive this information promptly.

3. The reorder point for a certain material, 3000 units, gives the purchasing department ample time to get prices, place an order, and deliver the material by the normal means of transportation. A stock factor of 1.07 is used in determining this reorder point. This item is used at an average of 200 units per day. In an emergency, the purchasing department can get delivery of it in 4 days. The storeroom uses a physical minimum to indicate the danger point in inventory.
   (a) What is the normal procurement time that is being allowed for this material?
   (b) What considerations enter into the determination of the danger point for this material? What should be its physical minimum?
   (c) What kind of a staff problem is created, if the stock on hand falls to the danger point. What staff functions are involved. Who should take what action? Where should he take it, and why?
4. In the central stores warehouse of a certain concern, several men do such work as repairing goggles turned in by workmen in the grinding room, reclaiming valves and other pipe fittings replaced by the maintenance department in making building repairs, etc. A group leader, or working foreman, is in charge of these men. Two or three bays or sections in the warehouse have been set aside for this work.
   (a) What function is being performed?
   (b) In what stage of differentiation is it? If it is further expanded, along what lines may it develop?

CHAPTER 22 • Personnel Management

The Development of Personnel Management

THE preceding chapters have dealt largely with the utilization of the organization's physical factors and forces. These implement the individuals and groups composing the company, and are correspondingly important. However, the problems growing out of the utilization of human forces are quite as important, and often are more difficult to handle.

The development of modern management was discussed briefly in Chapter 1. The background of personnel and industrial-relations problems extends far into the past, as was pointed out. Nevertheless, World War I brought home to industry generally the great losses that result from the poor handling of labor problems. These problems must be handled by a specialized organization which gives fair consideration to the workers' interests, as well as those of executives, investors, and consumers. These same problems could not be left wholly to production executives. In many cases, management's realization that industry has a social as well as an economic obligation was the underlying cause of the development of a personnel department.

The community of interest between employer and employee was more apparent when industrial units were small. The owner-manager often worked at the bench with his men. He consequently had intimate contact with them. He knew them personally in many cases. His men, on the other hand, were not entirely unaware of the difficulties which he encountered in managing his shop and in getting enough business to keep it going. Employees in the large factories of today often have little conception of the work of manufacturing management, and almost none of sales and finance. This condition has been recognized, of course, by many modern executives in progressive concerns. It is usually a function of the personnel department, in such concerns, to establish adequate channels of communication and to provide company information for employees.

In every factory, disagreements and misunderstandings develop between executives and their subordinates. Most of them should be adjusted satisfactorily and without much difficulty. Many strikes have been caused merely by the accumulation, over a period of years, of countless petty annoyances, irritations, and injustices that were not adjusted satisfactorily. Not so long ago, a factory foreman was virtually a czar in his particular department. He fired men at his discretion. His men had little recourse from his decision concerning their grievances. In many cases, management disregarded the principle that executive leadership requires the reasonable integration and satisfaction of all interests concerned with the industrial enterprise to be successful for any length of time. This includes the interests of employees and the public as well as of managers and investors. Management tended, in some cases, to regard labor as an item of business expense rather than an integral part of the organization, and to give it little further consideration after paying the current rate for it. This failure to realize its leadership responsibilities to its operative personnel often engendered a feeling of injustice and insecurity in industry. It should be noted that some of the pioneers in industrial and personnel management recognized the probable future consequences of these failures and warned against them. These problems, large and small, were given outstanding prominence by the economic and social repercussions of the great depression of 1929-1932. These were reflected in the National Industrial Recovery Act, the National Labor Relations Act, the Social Security Act, the Fair Labor Standards Act, and other social legislation affecting industry. A favorable "political climate" fostered the rapid growth of labor unionism.

During World War II, industry was faced with the problem of expanding, greatly and rapidly, its production of war materiel. It was expected, at the same time, to support a minimum-comfort level of subsistence for the civilian population. Industry had to do this despite critical labor shortages of various kinds and types. A National War Labor Board established critical labor areas, issued labor priorities to employers, attempted to freeze wage rates, and took other measures. Labor relations remained under the jurisdiction of the National Labor Relations Board. Management's control of an important factor in production, labor, was limited substantially.

Many events have taken place since World War II that have affected greatly the work of the personnel executive. There has been a great development of employee "fringe benefits." These may amount to 15 percent of the employee's base hourly rate, or more. The big labor unions

have become an important political influence, both nationally and in many industrial states. They have acquired a monopoly of the right to work in some industries. The automation of industrial operations may increase the power of some national unions, rather than decrease it. There are many special problems, such as the movement for the guaranteed annual wage, and its possible consequences.

The most notable general development possibly is the progress that has been made by some industrial executives in recapturing the leadership of their operative employees. The National Labor Relations (Wagner) Act was superseded in 1948 by the Labor-Management Relations (Taft-Hartley) Act. The Wagner Act established, among other things, the rights of professional labor leaders in labor disputes. The Taft-Hartley Act established a sort of "bill of rights" for business executives, as we shall see shortly. This included certain freedoms of speech for the discussion of labor matters in dispute. Such rights are not too significant, however, unless executive leadership has a sound doctrine, or management philosophy, that is known, understood and accepted by the rank and file. It is in this area that some progress has been made. It is important, even though it has been limited and spotty.

The effective management of an industrial enterprise depends on the executive's ability to lead subordinate employees in the accomplishment of the organization's economic and social objectives. Such leadership can be exercised without weakening the right of collective bargaining or the effectiveness of labor organizations in advancing the personal objectives of operatives. Credit for strengthening the position of executive leadership in industry must be shared by the personnel executive with a more enlightened professional top management that has been developing in many companies.

It is evident that the personnel executive has to deal with many problems that did not exist before World War II, or even 10 years ago. The origin of many of them lies far beyond the confines of his company.

The Objectives and Functions of the Personnel Division

The function of personnel management includes some important staff duties and responsibilities, which have to do primarily with the work of planning and organizing for the proper use of the human factor in serving the customers. It has other important responsibilities that have to do with a reasonable satisfaction of the employees' personal objectives. Personnel management contributes to the accomplishment of certain other collateral objectives of a broader social nature. These other values include

certain facilitative services for line and other staff components of the organization. These include assistance in the development of understudies for executive personnel. Personnel management aids in developing lines of promotion within the company. It keeps various personnel records. It assists in the promotion process in other ways. The personnel division handles transfers when requested by the line organization. It facilitates the adjustment of the organization to increases or decreases in business volume, through its employment and training functions. The division can contribute greatly to the permanent growth of the company by assisting in selecting candidates for executive positions. It can provide opportunities for executive self-development. These functions are concerned primarily with such values as organizational stability, flexibility, and capacity for growth. These values are objectives in the development of sound organization structure. General responsibility for organizational planning may be located, however, in the office of a top administrative staff executive. It is evident, nevertheless, that the personnel executive should participate in such planning. He may have staff responsibility for it at the plant level.

It has been noted above that the immediate objectives of the personnel division are secondary and collateral to the company's primary mission of customer service. These values are highly important and necessary to the accomplishment of its primary mission, nevertheless. The work of providing them requires that personnel executives have a specialized background, training, and experience of a professional nature. This work includes personnel planning and certain facilitative services. It is evident, therefore, that the personnel division is a technical staff organization.

The Personnel Organization

Any function tends to divide and separate itself into is components and subcomponents as the load of work grows. This has been called functional differentiation. A hierarchy of functions begins to grow downward from the original function. This has been called functional devolution. The executive who heads this hierarchy and the corresponding chain of command personifies the function. He should be personally accountable for the accomplishment of its objectives. Certain phases of his work must be differentiated from time to time and set up in an independent position. It is necessary to relieve him of his growing load of work and to provide for managerial specialization. This has been called staff evolution. The growth and development of any function, either line or staff, consequently tends to follow a basic form or pattern of structural relationships. The logic of this pattern was discussed in connection with Fig. 4.3. The extent and

detail of development will vary between companies and industries, but the basic pattern tends to persist.

A major technical staff function is subject to these tendencies. If its principal objectives are plans, the principal chain of command of a staff organization leads to staff specialization in planning. This organization will usually perform, in addition, some secondary functions of facilitation. If the principal objectives of this staff group are values that make it easier for other organizations to execute plans; the principal chain of command of the group leads then to staff specialization in facilitation. The group will usually perform, in addition, some secondary functions of planning.

The functional chart in Fig. 22.1 illustrates the application of these concepts to a personnel organization.[1] The personnel function in this chart is headed by a divisional vice-president in charge of personnel and industrial relations. He appears to be a headquarters staff executive in a large corporation. The departments in his organization evidently perform certain staff facilitative services for the headquarters office personnel. These departments should also assist the vice-president in his discharge of his responsibilities as a headquarters general personnel executive. These responsibilities have to do largely with technical planning and coördination, in the field of personnel management and industrial relations, between the divisions and plants of the corporation. The nature of these responsibilities is indicated by the general duty assignments in Fig. 22.1. There should be some parallel development of personnel organization at the plant level, as suggested in Fig. 15.5. The plant personnel manager will be accountable to the plant manager, however, since responsibility and authority in this corporation are decentralized on a product-line, profit-center basis. Most of the staff personnel work at the latter level is facilitative. The structure of the personnel organization therefore tends to be based on some grouping of facilitative functions of staff personnel management. Some of the more important groups may be separate departments in a large corporation. These are (1) employment, (2) medical, (3) safety, (4) education and training, (5) employee relations, (6) employee service, and (7) wage and salary administration. These departments are busy usually with the provision of important services. They may have little time in which to engage in detailed planning and research for

[1] Figure 22.1 is a minor modification of a chart in Ralph C. Davis, *The Fundamentals of Top Management*, Harper & Brothers, 1951, Chapter 7. The chart would give a functional breakdown of each of the personnel departments if it were completely functional. A very good example of a functional chart appears in Edgar G. Williams, *Indiana Personnel Executives—Their Programs and Practices*, Indiana State Chamber of Commerce, 1952. The chart is reprinted in Michael J. Jucius, *Personnel Management*, Richard Irwin, Inc., 1955, Chapter 4.

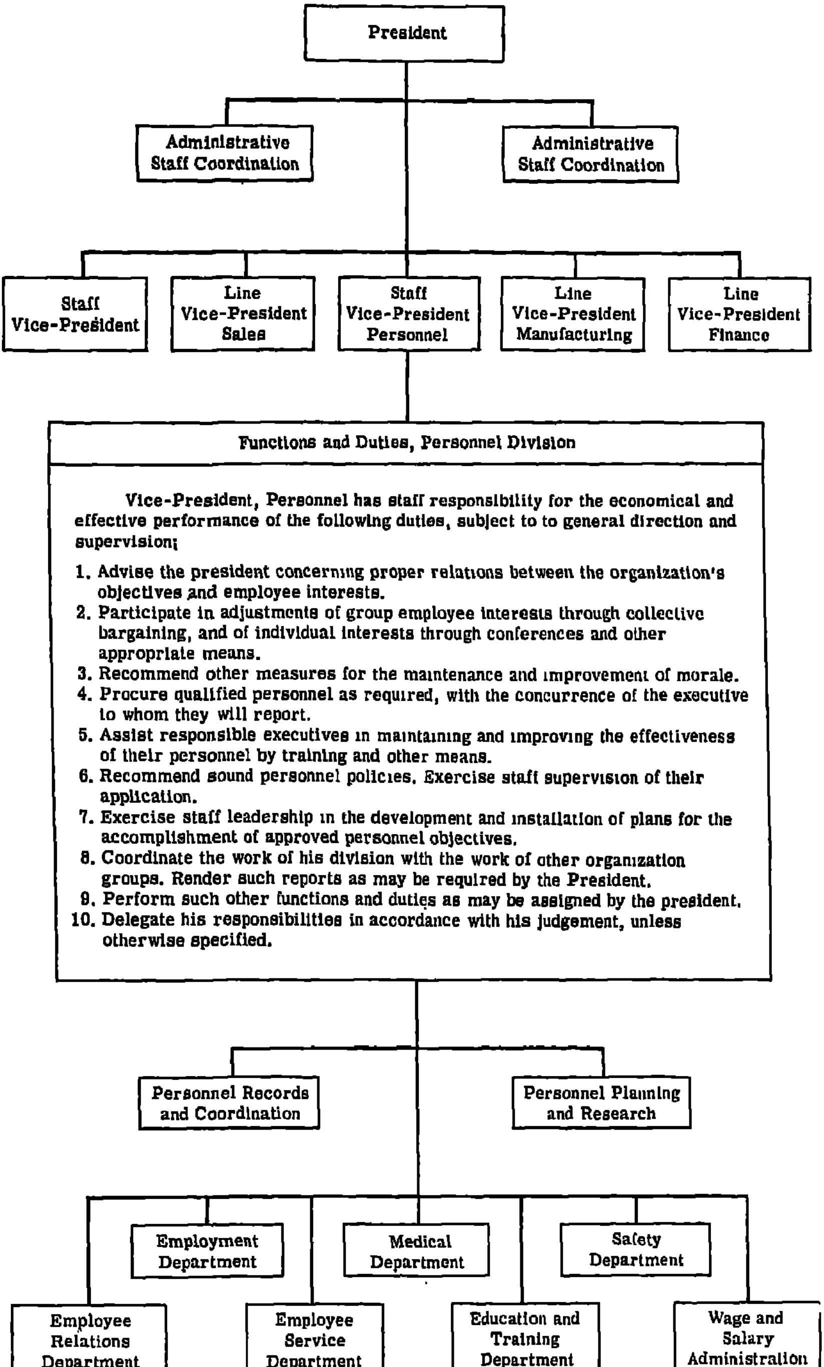


Fig. 22.1. A Functional Chart of a Staff Personnel Organization

the growth and development of their particular services. A personnel organization has 4 courses in such case: it can set up its own staff organization for personnel planning and research; hire a consultant to do the preliminary planning for it; break someone loose from a particular personnel department and assign the problem to him as a special project; or the head of the department can do the planning after hours, Saturdays, or at other times when he is free. There is another alternative, of course: do nothing, which may be the organizational equivalent of sweeping the problem under the rug. None of these alternatives is entirely satisfactory. In Fig. 22.1 a department for personnel planning and research under the vice-president for personnel and industrial relations was set up. This was done since this is evidently a large staff division of a large corporation. A secondary staff function of personnel records and coördination also is shown. This is the office of the vice-president, which coördinates internally the programs and activities of the division. This office may maintain liaison with the line and other staff divisions, except for the routine operations of the various personnel departments.

The work of the principal departments of a personnel division will be summarized in subsequent chapters. Only the general nature of the work at this point will be indicated. The employment department carries on most of the work of selecting, hiring, transferring, promoting, and releasing operative employees. These are facilitative functions that are performed with the approval of the line or staff organizations being served. These have to do with labor procurement and supply, obviously. This department may also perform these functions for executive employees, but only up to some designated managerial level. The medical department's function is to keep the employees in good physical condition, protecting them against occupational health hazards as much as possible. The department is usually responsible for the physical examination of new employees, and in some cases the periodic examination of the permanent force. It renders emergency medical services, gives first-aid training, inspects plant sanitary conditions, provides health education, etc. The safety department handles problems of safety education and training, runs safety contests, coöperates with the manufacturing methods division in the selection and design of safety devices, and performs other functions that are designed to reduce accidents. The education and training department is concerned with the development of the necessary skills and knowledges in the company's employees. Its activities may range from the operation of apprentice schools, through foremanship training programs, to the general education of the work force in the management philosophy

of the particular organization. Education concerning the company's management philosophy is intended to provide a basis for morale development. The employee relations department also is concerned with morale development and maintenance. It handles problems of union contract administration, employees' grievances when they get beyond the supervisory level, and similar employee relations problems. Union contract negotiations will be handled under the personal direction of the vice-president in charge of personnel and industrial relations, subject to higher line approval. The vice-president has the support of his employee relations department in these negotiations, and of any other staff organizations in the corporation that he may need. The employee service department operates the various plans of the company that provide benefits for employees, in addition to wages, hours, and working conditions. These plans may have to do with pensions, health insurance, recreation, and many others. These plans, as we shall see shortly, may be quite costly to the company, and ultimately to the consumer. The wage and salary administration section or department operates the company's plans for job evaluation, wage and salary surveys, promotion in pay, and similar problems. The analogous services for general administrative executives, and possible major operative executives, may be performed by a group under a vice-president for general administrative staff services. The reasons for this separation have to do with long-range business planning, rather than financial secrecy: the salaries of top administrative executives are published frequently in the company's annual stockholders' report. It should be remembered that the above functions render staff services. The personnel department or division is no different than any other staff organization in this respect. It must serve the line organization without dominating it. The leadership of its executives is basically advisory and facilitative.

The extent to which the functions of any staff organization are developed and differentiated depends on the objectives that are set for the organization, as well as the size of the company. The values that must be provided by the organization depend on the company's mission, as well as on the ideas of its top line executives. The structure of the personnel department will vary, in consequence, between companies. Figure 22.2 charts the current organization structure of a successful divisional personnel organization in the aviation industry. The differences between it and the chart in Fig. 22.1 are minor, and probably of little consequence for reasons stated above.

In general, staff supports line as noted previously. It represents overhead expense in consequence. There are usually certain man-power

strength ratios that should be maintained in order to be competitive in costs as well as in services. These ratios will vary between companies and industries. They tend also to limit the extent to which staff groups in a particular company in a certain industry can be developed. Dale Yoder has found that normally the ratio of the number of staff personnel employees per 100 served is 0.80, or 0.8 percent of total operative personnel.[2] A survey by Baker and Davis showed that the ratio of staff personnel employees to total line operative personnel was 1.4 percent, in a sample of Ohio manufacturing concerns.[3] These ratios will produce

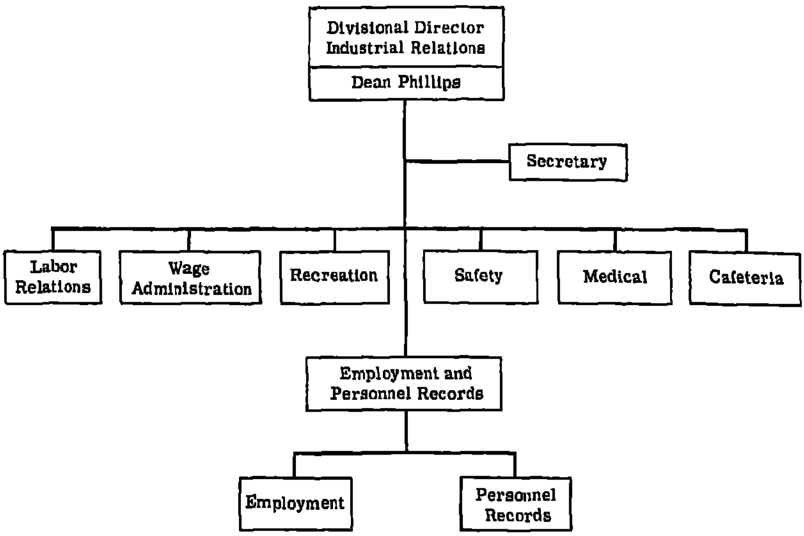


Fig. 22.2. The Personnel Organization of the Columbus Division of the North American Aviation Corp. (Courtesy, North American Aviation Corp.)

approximately the same estimate of required man-power strength for the personnel department, when the ratio of total staff operative personnel to total line operative personnel is approximately 75 percent. The table of organization for the personnel department would permit a total of 8 staff operatives, approximately, with a total operative strength of 1000 employees; 80 operatives in a concern with 10,000 employees. There may

[2] Dale Yoder, *Personnel Principles and Policies*, Prentice-Hall, Inc., 1952, p. 36.
[3] A. W. Baker, and R. C. Davis, *Ratios of Staff to Line Employees and Stages of Differentiation of Staff Functions*, Research Monograph 72, Bureau of Business Research, Ohio State University, 1954, p. 34. The total staff/line ratio for the data in this study is also 75%. The correct average ratio is probably higher, since the survey covered only the principal staff groups in a manufacturing organization.

be no staff personnel function in plants employing less than 100 employees. It may still be integrated with other functions of the line executives.

The Personnel Manager

The personnel manager's professional status is well established today in most progressive concerns. The personnel manager and his department advise and assist in the solution of problems involving the use and control of human rather than mechanical forces. This is a staff service whose functions are often delicate and complex. To direct and supervise this work effectively, the personnel executive should have tact and personality as well as ability. His work will be handicapped seriously if he is unable to win the confidence of the plant personnel, both executive and operative. In dealing with organized groups of employees, the personnel executive must be something of a diplomat. The relations between these groups and management are affected by a growing body of statutory and administrative regulations. He must have a working knowledge of them, because they enter directly into the formulation of personnel policies. Today most industries are affected with a public interest, either locally or nationally, or both. They are expected to make some contributions to certain social objectives such as economic security, the maintenance of purchasing power, the regularization of business activity, etc. Public relations and industrial relations are now closely related; in fact, the personnel executive is sometimes called the director of public and industrial relations. From this it is evident that he must have a broad social and economic outlook on his work.

There is also a business and administrative side to the personnel executive's work which is equally important. Personnel work is largely a staff phase of organizing. The personnel executive should have a good understanding of the economics of organization and its practical application to his company. He must not only have a good knowledge of the technique of personnel management, but must be able to put that knowledge into successful practice. This executive must also be able to organize his department so that the plant's day-to-day labor problems will be handled quickly and smoothly, as far as the personnel department is concerned. Finally, his department must be able to make sufficient tangible contributions to the company's successful operation to justify his place on its payroll. It is therefore desirable that he have some practical experience in its field of manufacturing. He is expected, of course, to make his staff contributions in the field of man-power supply and human relations.

The extent to which these qualifications can be expected of the per-

sonnel executive is in large part a function of the size of the concern and its volume of business. The personnel manager of a large concern is likely to have all of them and more. It is quite certain that he will be a high-grade executive, and that he will hold high rank in the company, possibly that of vice-president. In a small concern, on the other hand, he is often little more than a high-grade clerk. The line executives, in other words, are the real personnel executives in the small plant.

PROBLEMS

1. A firm manufacturing a diversified line of items which include rubber footwear, raincoats, woolen hose, coated fabrics, and plastic products, employs 8000 workers. The personnel department, consisting of about 60 employees, includes the following units: labor relations, male and female employment sections, male and female employee training sections, employee publicity, medical, employee services, safety, and general personnel (which includes a variety of miscellaneous activities). Another firm in the same city produces special-purpose heavy machinery. The latter company has a payroll of 950 employees. It includes the following units in its personnel department; employment, training, medical, safety, and employee services. There is no designated section for labor relations: The head of the personnel department personally conducts all labor negotiations and other staff liaison with the local union. The entire personnel department, in the latter company, includes 13 employees. Although these two firms differ considerably as to size and basic operations, the organization of their personnel departments is remarkably similar.
   (a) Is the similarity due to emulation of one firm by the other, in your opinion, or is this due to some other reason? Explain.
   (b) Are these companies adequately staffed for the accomplishment of their assigned mission, in so far as personnel strength is concerned? How do you know?

CHAPTER 23 •

• Personnel Procurement and Organizational Maintenance

The Labor Supply Problem

LABOR supply, using the term in a broad sense, includes the problem of providing an adequate number of the right kind of executive and operative employees. What is the right kind of employee depends, of course, on the work contents and personnel requirements of the particular jobs that must be filled. The principal phases of the problem have to do with (a) the administrative management of labor supply, and (b) the operative management of labor supply.

The administrative phase includes two major problems. One is the development of an inventory of executive personnel that is adequate for continuing organizational growth, as well as the staffing of the present organization structure. This gets into the matter of executive development programs. Executive development for the levels of general administrative management is associated closely, in large organizations, with long-range organizational planning. This function may be assigned to a top administrative staff services group for this reason. Executive development for major operative and supervisory management levels is usually the staff responsibility of the personnel division. The entire problem of executive development will be discussed briefly when we look into the work of the education and training department. The other major problem is the development of a labor requirements program. It involves the breakdown of the production program to determine future personnel requirements by labor classes and departments. A general method of approach to the problem will be discussed shortly.

The operative management phase of the problem also includes two major problems. One of them is concerned with action to execute a current phase of a labor procurement program. The other problem is concerned

with current action to maintain the present organization. It may be necessary to replace quits and discharges. Replacements for transfers and promotions must be secured. Any work of labor procurement for current needs will be affected probably by manufacturing policy decisions concerning such matters as shift hours, overtime, etc.

The Labor Requirements Program

A labor requirements program is a statement of the number of operatives, by labor classes, that will be required to man each department during designated future time periods. A purchase delivery schedule coördinates the procurement of direct materials with the requirements of the manufacturing line organization for such materials. It gives the supply division sufficient lead time to enable it to perform its services economically and effectively. The labor requirements program does the same thing for the personnel division in so far as the procurement of operative personnel is concerned. This program gives the employment department sufficient time to find the required number of people for an operating department and to select those who are most suitable for the required work. It gives the education and training department an opportunity to give new employees the required basic training. The department manager or foreman has time then to do a satisfactory job of finish training. There is a greater opportunity to transfer people when it is evident in advance that the amount of work in certain departments will go down. Labor programming contributes other values that make it good business practice. The general method of approach to the problem may be summarized as follows:

1. Sales forecasting
2. The development of a production program
3. The determination of departmental production requirements
4. The determination of weekly man-hour requirements bl labor classes and departments
5. The conversion of man-hour requirements into number of men required by labor classes, departments, and weeks
6. Transmission of the labor requirements program by the production control department to the personnel division
7. The adjustment of the labor requirements program by the personnel division to get an employment program
8. The execution of the employment program by the employment department
9. The administrative control of labor supply

The above approach is sufficiently fundamental to cover the problem under conditions of continuous or intermittent manufacturing. Any pro-

cedure would be designed, of course, to fit the needs of each company. The particular needs are determined by its size, organization structure, and other conditions.

The problems of sales forecasting and the development of production programs have been covered previously in the discussions of the marketing and production control functions. These are mentioned because the procedure for determining labor requirements is an extension of the methods for determining parts and assembly production requirements.

The determination of departmental production and labor requirements may require some further comment, however. The production program merely sets up the requirements for finished products either by future dates or time periods. Figure 16.7 illustrated the manner in which the production of parts, subassemblies, and final assemblies are related either to the production program or the shipping order by means of lead time. A glance at Fig. 16.7 will show that whatever labor is required for parts 6 and 11 must be available in the starting departments at least by the beginning of the sixth week before shipment of the finished product is intended. Whatever labor is required for parts 1, 4, 8, and 10 must be available, similarly, in their starting departments at least by the beginning of the fifth week before shipment. It is possible to determine also what operations on what parts should be running in which departments during the sixth, fifth, fourth, third, etc., weeks before shipment. Some concerns prefer to set up this information statistically, rather than graphically as in Fig. 16.7. This can be done furthermore, for each end product that appears in the production program, in addition to product 121 in Fig. 16.7.

The operation layout sheet shown in Fig. 9.7 states the class of labor that is to be used for each operation on the particular part. It states also the standard time for the performance of each operation. This time can be entered on the above tabulation opposite each operation on each part. The same thing can be done for subassemblies and final assemblies that must be completed by our assembly departments. The multiplication of unit time requirements for an operation by the production requirements for the particular part or assembly during the time period gives the time of the class of labor that is required for the particular operation. The standard time requirements for the class of labor must then be increased or decreased, depending on whether the departmental productive labor efficiency is below or above 100 percent. The operation layout sheet for part X, in Fig. 9.7 is used to illustrate the general method of determining weekly departmental man-hour requirements.

Department number	12
Part number	X
Operation number	1
Number of the week during which operation will be running in the department (This is usually the first week in May.)	18
Production requirement for the part (The monthly requirements for this part will be run on a production order as a single lot. Operation 1 is scheduled for Dept. 12 during week 18.)	1000 pcs
Unit process time	
Setup time	20.0 min
Unit machine time	0.236 min
Time to process the operation [20 min + (1000 pcs × 0.236 min)]	256 min
Departmental productive labor efficiency	85.0%
Labor class used on the operation	Class 21
Man-hours of Class 21 labor required for this operation during week 18 [256 min ÷ (60 × 0.85)]	5 man-hours

The order under which this operation is being run will provide a little more than a half day's work for one Class 21 operative in this department. This is likely to be the case in a plant that manufactures assembled products under conditions of intermittent manufacturing. Many different orders that require Class 21 labor may move through Department 12 during week 18, however. The departmental payroll may carry a number of operatives in this labor classification. It may be possible to keep all of them busy during the week for the standard 40 hours.

The man-hours of labor required must be converted into number of men required. This is merely a matter of dividing the number of man-hours for the class of labor by the number of hours expected to be run during the week. It will be assumed that the department will run a standard 40 hours per week and that the total man-hours of Class 21 labor required by Department 12 for week 18 is 82.6. It is obvious that two men in this class will be required by the department. Careful departmental scheduling of work assignments may be necessary to avoid overtime for these men. The departmental labor efficiency should be above 100 percent if the men are working under a wage incentive plan. Any substantial increase in efficiency would eliminate the need for overtime. There are other ways of avoiding it, of course.

No advance planning is exactly accurate. The actual sales order mix for any given month will be different probably from the mix set up by

the sales program. It will be recalled that the production program differs usually from the sales program. It is possible, therefore, to have more work in some departments than we expected, and less in others, in spite of good sales and production planning. Some shifts in plans and personnel between departments may be necessary. It follows that management is interested in departmental labor requirements, but plant totals for each labor class for each week may be equally significant.

The labor requirements program, then, is a consolidation of the departmental analyses. It will state the number of operatives by labor classes that will be required to man each department during coming weeks. The program will show the totals for these classes for the plant. It is probable that the production control department is the agency that will be required to develop this program for reasons noted above. To procure and maintain the required man power is the responsibility of our personnel division. The line organization, nevertheless, must product salable product economically with the men, materials, and machines at its command. It is therefore likely that some important conferences between line and staff division heads must be held before the various programs, including labor requirements, are finally approved by a top line executive. The labor program will be forwarded to personnel for execution, after approval.

The development of such a program may appear to be a difficult, time-consuming, expensive operation. That is because it has been done the hard way to make clear the nature of the factors, forces, and effects in the problem. There are many ways in which the procedure could be simplified. A large corporation, for example, is likely to have some modern data-processing equipment. It is probable, that the required data and relationships would be set up on punch cards or tape for tabulation and computation by such equipment. This work might be done for production control, furthermore, by a computing and tabulating department under the office manager. The whole job might be done in a few hours at little expense. It might pay to do it this way, since forecasts and programs usually are revised monthly.

The personnel division has a right to expect production control to furnish a statement of personnel requirements for coming weeks and months. It is the responsibility of the division to develop its employment program. This program is of interest to employment, medical, and other personnel departments. The program therefore may be worked out by the office and records section of the division, with the concurrence of the employment manager. This section is shown in Fig. 22.1. The principal adjust-

ments of the labor requirements program would have to do with labor turnover. The following is the basic relationship for the adjustment:

(Number to be hired or released) = (Authorized personnel strength) + (Personnel losses due to transfers, quits, etc.) − (Present personnel strength.)

It will be assumed, for example, that the requirements for Class 21 labor for all departments during a coming month is 33,000 man-hours. It is expected that the plant will work 165 hours during the month. The average monthly turnover for the plant is 60 percent per year, or 5 percent per month. The total present strength in this classification is 215 men. Then

$$N = \text{Total number to be hired or released}$$
$$= (33{,}000/165)1.05 - 215 \text{ men, or } -5 \text{ men}$$

It is probable that the plant must lay off 5 men in this classification, unless the men can be transferred to other work. The breakdown by departments should indicate where such action may be necessary.

The immediate responsibility for the execution of the employment program should rest on the employment manager, of course. He should receive his copy sufficiently in advance of the time when man power is required to permit proper execution by his department. A poor job of personnel procurement and selection may be done by a good employment department because it has not been given sufficient time and staff to perform its functions satisfactorily. We shall look shortly at the general nature and requirements of these functions.

Good procedure provides a good basis for coördination, but it is not the work of coördinating. The latter is a function of control, either line or staff. It is necessary that the staff function of labor procurement be coördinated with the functions of the line organization that need the labor. Production control again may have staff responsibility for such coördination, if we are talking about the line function of production. The writer observed the effects of poor coördination in a rapidly expanding organization during World War II. The personnel division was pumping people into the organization in accordance with plan. The manufacturing division did not increase the rate of production in accordance with plan. The result, for a short time, was a 55 percent utilization of labor. Morale was low, in consequence. The same condition can develop in peacetime, of course, but it should not in any such degree. Some administrative control of labor supply is necessary to prevent it, however. Assume, for example, that every directly productive operation in a certain plant has a standard time

for its completion. Production control should have a record of every order shipped from each directly productive department of the plant. It should know, obviously, the operations that have been performed on each order. It should be able, then, to compute a labor utilization ratio for each department, weekly and monthly. Assume, further, that there are 50 directly productive operatives in a certain department. They clocked 2100 hours during a given week, including overtime. The standard hours of work shipped from the department during the week totaled 2142 hours. The operatives are working under standards and wage incentives. The productive labor efficiency of the department for incentives work is 120 percent. In such case,

$$\text{Labor Utilization} = \frac{(\text{Standard Hours Shipped})}{(\text{Directly-Productive Hours Clocked}) \times (\text{Production Efficiency})}$$
$$= \frac{2142}{2100 \times 1.20} \times 100, \text{ or } 85\% \text{ utilization}$$

This department is supposed to be entirely on standards and incentives. It may be that too many directly productive operatives are being given day work to keep them busy. The payroll of this department could be reduced by approximately 4 men if labor utilization could be increased to 97 percent. This is an equivalent annual saving of $15,000 per year, if the men have average earnings of $1.90 per hour. It would be the responsibility of the employment manager to call apparent labor surpluses to the attention of the responsible line executive. He should check into the situation if necessary. The personnel division would receive copies of any labor utilization reports originated by production control, as well as higher line executives. There are other administrative measures that show the condition of personnel strength by organizational components. The personnel division may compute man-power ratios by departments and divisions, showing the relation of actual to allowed personnel strength. The comptroller's division may report payroll budget variances. Nothing has been said about the procurement of staff operatives. Some concerns use standard staff-line personnel ratios to measure the allowable personnel strength of staff departments. The marketing division has a similar but different problem of determining its labor requirements, both executive and operative. A detailed discussion of labor requirements problems must be left to advanced texts.

The Employment Procedure

The employment department has to maintain as well as build up the required personnel strength of the various departments composing the

organization. The reverse may be true during a period of business decline. The following discussion assumes that we are replacing an employee who has been separated from the payroll of a department. The procedure will illustrate the problems involved in procuring, selecting, and placing people in job vacancies in any case. The principal steps in the procedure are:

1. Authorization of employment action by the personnel division
2. Recording and servicing the requisition by the division's office
3. The determination of the source of labor supply to be used
4. The collection of employment information
5. The formulation of the employment decision
6. The closure of the employment procedure for the particular case
7. The induction of the employee into the organization

The purpose of the procedure is to fill the vacancy with a person who is qualified to do the work or can be trained for it. The person must be available, of course, when he is needed. He should be handled in a manner that will facilitate the development of a loyal, satisfied employee; not merely one who is competent to do the job. The cost of performing the employment function should not be excessive. These and other requirements must be met by a good employment procedure.

Personnel Office Layout

Physical environment conditions the economy and effectiveness with which any functions are performed. This is particularly true of personnel functions, dealing with human factors and forces. It therefore may be helpful to take a brief look at the personnel office layout. The example in Fig. 23.1 will do for discussion purposes.[1] The particular company is evidently not a large one, however. No space provisions have been made for such personnel functions as employee relations, safety, wage and salary administration, and personnel planning and research. This means that these are performed either by the line organization, some other staff department, the personnel manager personally, or not performed at all.

The personnel department should have adequate facilities for handling the flow of applicants seeking employment. The employment office in many plants is a small, unattractive place in a corner of a building adjacent to the street. The applicant's first impressions are largely negative, in consequence. These impressions may subsequently be a significant factor in the work of morale building. Many progressive concerns provide cheer-

[1] The reader may find it interesting to compare this layout with that of the Inland Steel Products Company, as shown in the July 15, 1953 issue of *Modern Industry*. A semigraphic presentation of the employment procedure accompanies the layout diagram.

ful, attractive employment offices equipped with adequate seating capacity for this reason. Such an office makes a better impression on the applicant for whom there is no work. There is greater probability that he will apply for work, when it becomes available later. The company's relations with applicants for work may appreciably affect public relations in its community.

In the layout in Fig. 23.1, the waiting room, interviewers' offices, medical department, and exits are so arranged that the flow of applicants approximates a straight line as far as possible. This reduces the possibility of congestion in the office, and assures privacy in interviews.

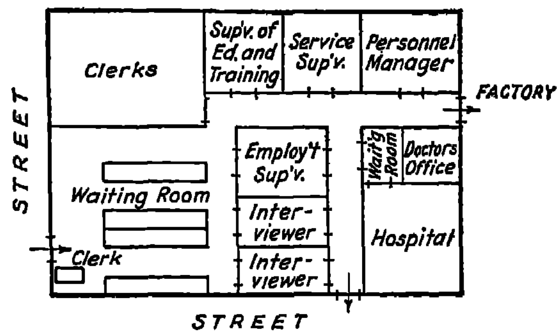


Fig. 23.1. A Personnel Office Layout

Authorizing Employment Action

The employment department is a staff agency, operating under the immediate direction of the employment manager, and the general direction of the personnel director. It supports the line organization to which it is attached by performing duties having to do with hiring, transfers, layoffs, separations, and other labor procurement activities as assigned. It acts for a higher line executive and his line subordinates. Its actions must have line authorization, in some form, therefore. The department may serve other staff organizations, of course, particularly when attached to the same chain of command.

There are two principal instruments which may convey the authority to employ people; the employment program and the labor requisition. As shown previously, the employment program has received the concurrence of the line subordinates who are affected, and the approval of higher line authority. It obviously conveys the authority to hire people for the departments indicated in the labor classes and numbers shown.

The labor requisition is usually an authorization and request to procure

certain personnel for the current needs of a department. A foreman, for example, may originate a requisition for the replacement of a man, in a certain labor classification, who has quit on the night shift. The labor requisition may be the only instrument for employment authorization. This is likely to be the case when the production control department has not been required to furnish the personnel division with a labor requirements program. It may be possible for the foreman, in such case, to increase the personnel strength of his night shift by originating requisitions for additional men. These requisitions must have the approval of his general foreman or superintendent, however, when they authorize a personnel increase. The requisition must carry sufficient information to permit the employment department to identify the particular personnel need. It gives such facts, therefore, as the department number, the job number, the shift, the number of male or female personnel needed, the date when wanted, and the authorizing signature.

There is probably a standard employment procedure. It should state who is responsible for doing what, where, how, in what order, who can make which decisions, and similar information. The procedure was worked up by the personnel division and approved by some higher line authority. It is in effect a standing order. It authorizes the use of specified methods and facilities, but it does not authorize action to fill a particular personnel need.

Recording and Servicing the Requisition

The labor requisition probably may be received by the personnel division office, in the case of the company in Fig. 22.1. This office may record the requisition in a labor journal. A file of labor requisitions, similar to the one shown in Fig. 23.2, can be used to perform the functions of a labor journal, however. The personnel division office may attach the job specification to the requisition unless a working file of specifications also is maintained in the employment office. The specification number and job number are usually identical. The nature of the specification will be discussed shortly. It may then forward the requisition, with the specification attached, to the employment manager for action. When the vacancies have been filled, the requisitions are routed back through the journal and the transaction is closed out, as far as the employment office is concerned.

Recording the requisition in the journal has several advantages. It assures that the requisition will not be overlooked if it is mislaid or cannot be filled promptly. Reports on requisitions outstanding give a check on

the efficiency with which they are being handled. The information in the journal can be summarized at the end of the month to provide a report of hirings by classes of labor and departments. When the company is expanding, a labor accessions ratio may be a more significant index of the changes in personnel than is a labor turnover ratio. It is not necessary to use a hand-posted journal to gain these advantages. We can get the same results, using electronic tabulating equipment, when the data on the labor requisition is punched into tabulating cards.

Form F-1105 (8-54) **REQUISITION FOR PERSONNEL** Date ____________

EMPLOYMENT OFFICE ____________ No. ____________

Please furnish the following:

NUMBER OF		OCCUPATION	RATE	SHIFT	REPORT TO
MEN	WOMEN				

DESCRIPTION OF JOB ____________

DELIVERY DESIRED: AS SOON AS POSSIBLE ____ WITHIN ____ DAYS ____ URGENT ____
CHECK ONE

SIGNED ____________

APPROVED ____________ DEP'T ____________

NOTE:—When requisitioning for special or particular positions, e. g., clerks, stenographers, draftsmen, mechanics, etc., give sufficient details and anticipate your wants as far as possible in order to allow Employment Office to make intelligent referrals. Phone requisitions must be covered by written form without delay.

RETAIN COPY OF THIS REQUISITION FOR YOUR FILES FOR CONTROL.

Fig. 23.2. A Labor Requisition. (Courtesy, Proctor & Gamble.)

Sources of Labor Supply

The procurement and development of an efficient working force requires adequate sources of supply from which the employment department can select a sufficient number of qualified individuals. When business is decreasing, the question of an adequate supply of labor may not be important. It becomes very important during periods of general business activity when most plants are expanding their production programs. In general, these sources may be classified as external and internal.

External sources are those outside of the company; casual applicants, files of previous applicants, schools and colleges, records of former employees, labor union offices, public and private employment agencies, and labor centers not immediately adjacent to the plant. There are various means of using these sources, such as personal interviews, labor scouts,

advertising, and correspondence. External sources are often used for operative employees during periods of abnormal seasonal or cyclical business expansion. This was quite noticeable during the post-Korean War boom. There was, for example, considerable advertising in out-of-town newspapers for engineering and other technical operatives and executives. This was done by many corporations in many industries.

The internal sources of the labor supply are largely within the company itself. These are particularly important in connection with vacancies in the permanent force. It is usually better to fill such vacancies by promotion, whenever possible, than to hire new employees. Less immediate training is necessary. There are fewer interruptions in the normal routine of production and management. There is greater probability that the vacancy will be filled permanently. Promotions, when properly handled, make a definite contribution to the morale of the more able and ambitious employees. This has a stimulating effect on the whole organization. There are still other advantages that have induced some concerns to work out definite promotion policies and logical steps of promotion. In spite of the fact that the total training problem and expense may be increased, most competent personnel executives believe that the advantages outweigh the disadvantages.

Some concerns solicit recommendations from their present employees. They are anxious to get their friends into the plant, if it is a good place to work. Such applicants are already favorably impressed with the plant. They have friends among the workers. The chances that they will be permanent are accordingly greater than in the case of the casual applicant. However, there is the danger of cliques developing if too many friends and relatives are employed in the same department.

The Collection of Employment Information

Effective performance of the employment process requires facts. The collection or provision of the necessary information concerning the requirements of the vacancy and the candidates for it is an important phase of the process. The employment manager in a large company may have a number of interviewers who specialize in different areas of employment: one may hire for office jobs, one for the machine shop, etc. The labor requisition, with the job specification attached, will go to the proper interviewer. It will then be his responsibility to collect the necessary facts, and to recommend a logical, equitable employment decision. The employment manager in a small organization may perform the entire

employment process with little or no assistance. We shall assume that we are dealing with the problem in a large plant. The principal sources of information that would be available to the interviewer in such case would be probably the labor requisition, the job specification, the service records of present employees, application blanks of prospective employees, reports of medical examinations, and reports of selection tests, if any are given.

Most organizations would try to fill a vacancy above the level of unskilled labor from within the company. This is not always practical, as we shall see shortly. The job specification, nevertheless, should show the job numbers of positions from which it may be possible to promote or transfer employees to fill the vacancy. Employee names and clock numbers should be cross-filed by job classification numbers for which they are qualified. The names should be flagged to show which employees have been doing the best job and show the greatest promise for further development. Some form of a service record is kept for each employee, whether executive or operative. Reference to the service records for a number of promising employees on eligible jobs may disclose a number of good candidates for the vacancy. They can then be called into the employment office for an interview. Some such system is necessary to coördinate vacancies in the permanent organization with the qualifications of employees who merit consideration for promotion or transfer. Length of service and seniority tend to be the principal consideration in the advancement of operative employees, in the absence of adequate employee service records. American management, in general, believes that it is unsound to promote or transfer chiefly on the basis of seniority. There may be no employee who wants the vacancy that has been discussed, and is qualified for it. It will be necessary, then, to hire a man from some outside source.

The Application Blank

The employment office should take care of an applicant quickly and effectively. A clerk is seated at a desk near the entrance to the office in Fig. 23.1. She gives a preliminary application blank to each applicant. The blank collects the minimum information that is necessary to screen the applicant for the job in which he is interested. An example is shown in Fig. 23.3. A buzzer or interphone notifies the clerk when a particular interviewer is at liberty. The applicant is sent to him with his application blank. In some concerns, the applicant first sees a junior interviewer who eliminates those obviously unfitted for the vacancy, and sends to a senior

PRELIMINARY APPLICATION
THE JAEGER MACHINE CO.

Birth Certificate Yes (X) No ( )

Name *John D. Doe*

Male (X) Female ( )

Address *431 S. Mill Ave. - Columbus, O.*

Date of Birth *3 - 25 - 20* (MO. DAY YR.)

Tel. No. *EV 1234*

Citizen of U.S.? ☒ YES ☐ NO

HEIGHT (*6'*) WEIGHT (*180*)

Single ( ) Married (✓) Widowed ( ) Divorced ( )

Social security No. *286-01-6325*

Dependants: No. Children (*2*) Others ( )

Selective Service Classification *3-A*

EDUCATION

	Check last year completed	Did you Graduate?	What Year?
Grammar School	5 6 7 8		
High or Preparatory School	1 2 3 ④	*Graduated in*	*1939*
College or Technical School	1 2 3 4		
Night or Special School	1 2 3 4		
Business College or Trade	1 2 3 4		
Others	1 2 3 4		

(OVER)

HOW MUCH EXPERIENCE HAVE YOU HAD ON THESE KINDS OF WORK OR MACHINES

	Less than 1 yr	1 to 5 years	Over 5 years	None		Less than 1 yr	1 to 5 years	Over 5 years	None
Blueprint Reading		*4*			Engine Lathe Operator				
Steel Fabrication					Turret Lathe Operator		*4*		
Sheet Metal Layout					Turret Lathe Setup		*3*		
Welder (Electric Arc)	*X Some*	*in*	*High School*		Spray Painting				
Burner (Acetylene)	*X Some*	*in*	*High School*		Tool Maker				
Punch Press					Boring Mill Hand				
Brake					Milling Machine Opr.				
Shear	*X Some*	*in*	*High School*		Radial Drill Opr.	*1*			
Molder					Assembly		*Approx.*	*9 yrs.*	*of*
Core Maker					Other Work		*Ass'y &*	*Mechanics*	

Employed ( ) Unemployed (✓)

Previous Employer's Addresses	Duties	From	To
Master Steel Machine Co. - Col., Ohio	*Lathe Operator*	*10-39*	*2-44*
U. S. Army	*Infantry*	*3-44*	*3-47*
Detroit Machine Shops Inc. - Col., Ohio	*Radial Drill Operator*	*3-47*	*5-48*
General Electric Corp. - Col., Ohio	*Assembler*	*5-48*	*2-56*

Date *2-2-56* Signature *John D. Doe*

OF-242 (OVER)

Fig. 23.3. An Application Blank. (Courtesy, Jaeger Machine Co.)

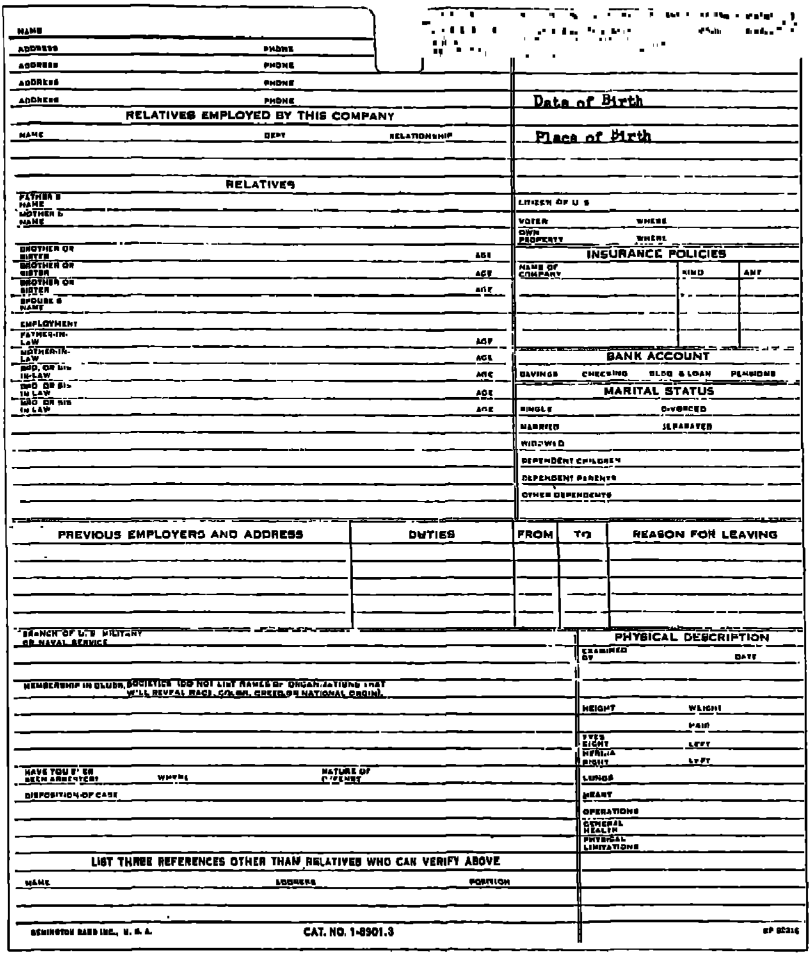

NAME
ADDRESS PHONE
ADDRESS PHONE
ADDRESS PHONE
ADDRESS PHONE
RELATIVES EMPLOYED BY THIS COMPANY
NAME DEPT RELATIONSHIP
RELATIVES
FATHER'S NAME
MOTHER'S NAME
BROTHER OR SISTER AGE
BROTHER OR SISTER AGE
BROTHER OR SISTER AGE
SPOUSE'S NAME
EMPLOYMENT
FATHER-IN-LAW AGE
MOTHER-IN-LAW AGE
BRO. OR SIS. IN-LAW AGE
BRO. OR SIS. IN LAW AGE
BRO. OR SIS. IN LAW AGE
Date of Birth
Place of Birth
CITIZEN OF U. S.
VOTER WHERE
OWN PROPERTY WHERE
INSURANCE POLICIES
NAME OF COMPANY KIND AMT
BANK ACCOUNT
SAVINGS CHECKING BLDG & LOAN PENSIONS
MARITAL STATUS
SINGLE DIVORCED
MARRIED SEPARATED
WIDOWED
DEPENDENT CHILDREN
DEPENDENT PARENTS
OTHER DEPENDENTS
PREVIOUS EMPLOYERS AND ADDRESS | DUTIES | FROM | TO | REASON FOR LEAVING
BRANCH OF U. S. MILITARY OR NAVAL SERVICE
MEMBERSHIP IN CLUBS, SOCIETIES (DO NOT LIST NAMES OF ORGANIZATIONS THAT WILL REVEAL RACE, COLOR, CREED OR NATIONAL ORIGIN)
HAVE YOU EVER BEEN ARRESTED? WHERE NATURE OF OFFENSE
DISPOSITION OF CASE
PHYSICAL DESCRIPTION
EXAMINED BY DATE
HEIGHT WEIGHT
HAIR
EYES SIGHT LEFT
HERNIA RIGHT LEFT
LUNGS
HEART
OPERATIONS
GENERAL HEALTH
PHYSICAL LIMITATIONS
LIST THREE REFERENCES OTHER THAN RELATIVES WHO CAN VERIFY ABOVE
NAME ADDRESS POSITION
REMINGTON RAND INC., U. S. A. CAT. NO. 1-8901.3

Fig. 23.4. An Application Blank and Employee Service Record. (Courtesy, Jaeger Machine Co.)

interviewer those applicants who seem eligible. The latter, after some further interview, may request the applicant to fill out a more detailed blank. It collects certain necessary information, in addition to that on the preliminary application blank. Both blanks become a part of the man's service record, if he is hired.

The application blank has a number of important functions. It conserves the interviewer's time by supplying him with information concerning the applicant's general characteristics and qualifications. It is necessary for the interviewer to secure only the additional information that requires

careful questioning, and the use of judgment. The blank may have on it space for summarizing the interviewer's evaluation of the applicant. The blank for operative employees may contain a form on which rate changes, transfers, promotions, etc., can be recorded later. This blank may then be used as a service record for those applicants who are hired. This is the case in Fig. 23.4. A separate record of job and rate changes may be kept, however, as in Fig. 23.7. If no job is open, the application blank may be filed by name and cross-filed by occupation, thus providing a source of information relating to the labor supply.

Many application blanks become practically valueless in a relatively short time. The applicants may have moved to other addresses, obtained satisfactory employment elsewhere, etc. To keep these files up to date, some concerns periodically strip the files of applications that have not been used within a given time.

The Job Specification

Some concerns spend more money per month on payroll than on inventory. For this reason it seems quite as logical to specify accurately and concisely the skill, knowledge, experience, age, and other requirements for a particular job as it does to specify in detail the attributes of a piece of steel for a particular production purpose. Some concerns have therefore developed job specifications for all work, both executive and operative. An example of an operative job specification is shown in Fig. 28.2. This will be discussed later in connection with problems of personnel research and standards. It will be pointed out then that a job specification may do more than supply employment information. It is sufficient to note here that a job specification supplies the interviewer with information relating chiefly to 3 basic business factors: (1) the general nature of the work to be done, (2) the physical conditions, environment, and requirements of the job, and (3) the qualifications that the worker must have. It may be objected that the experienced interviewer knows these things. He may, but not well enough to do a good job in many cases. Many purchasing agents raised the same type of objection when purchase specifications were introduced during the early years of the present century.

The requisition has supplied the interviewer with authority to fill the vacancy. It has provided information concerning the number of men required, what department needs them, when they should report, etc. The job specification has provided a detailed statement of the requirements of the job. The application blank has furnished a convenient but general statement of the applicant's characteristics and qualifications. However,

these instruments do not lessen the interviewer's need of judgment and experience, but merely aid him in conducting the interview.

The Interview

The interview is a method of obtaining facts from an individual, and of accomplishing a meeting of minds concerning the particular problem. Interviews may be held for a number of purposes. Some of them have to do with getting facts for planning or policy purposes, the administration of disciplinary action, the handling of grievances, the determination of the status of a project, and others. Interest here is in the use of the interview for employment purposes.

The interviewing technique that is used depends on the kind of interview that is thought to be most effective in the particular case. The principal kinds are:

1. *Unplanned Interviews:* The interviewer has an objective, but he does not decide in advance the questions that should be answered.
2. *Planned Interviews:* Some decisions are formulated in advance concerning what information is required to answer what pertinent questions concerning the particular problem and the man. Such interviews may be:
   a. *Planned Informally:* Certain general objectives and questions are formulated, but no pattern of questioning is worked out.
   b. *Planned Formally:* The general objectives, questions and pattern may be formulated in advance. In such case we may have
      1. *Guided or Directed Interviews,* in which the interviewer puts to the applicant or employee certain questions in a certain pattern, as determined by an interview questionnaire or planned list of questions.
      2. *Unguided, or Nondirected Interviews,* in which the interviewer merely keeps the individual talking. He may ask nondirective questions occasionally to stimulate the flow of statements until he feels that the planned questions have been covered.

The significant facts developed by the interview should be recorded and evaluated, of course. This is done directly on the application blank in many concerns. Some concerns use a printed interview questionnaire. This is more likely to be the case for purposes other than employment. It may be desirable, if one is used for employment, to fill it out after the interview has been concluded.

There are certain rules of interviewing that are considered usually to underlie good interviewing procedure. The following are some of them:

1. Decide in advance the facts that should be brought out. An interview without an objective is not likely to get anywhere.
2. Decide what kind of an interview is most likely to be effective in the particular situation.

3. Allow sufficient time for the interview to assure that all the required facts will be developed.
4. Get the confidence of the applicant or employee by respecting him as an individual, considering his interests and points of view, and by making him feel at ease.
5. Let the individual do the talking. He is the source of information.
6. Answer the individual's questions adequately, factually, but briefly. He has probably some legitimate interests in the problem that should be satisfied.
7. Watch the semantics of the conversation. The same words have different meanings for different people.
8. Provide reasonable privacy for interview.
9. Close the interview courteously and tactfully.
10. Use a trained, experienced interviewer who has the attributes of tact, judgment, personality, human sympathy, etc.

Many concerns follow the policy of giving every applicant some interview, regardless of whether there is a vacancy in which he is interested. They feel that a brusque statement that there is no work, or a sign to this effect on the door of the employment office, is poor public relations practice. It may be difficult to apply this policy, however, during times of severe unemployment when there may be an unusually large number of applicants.

We shall see later that many tests for selection have been developed. Most personnel executives, nevertheless, regard the work of interviewing as the principal process in selection. The interview, furthermore, is the applicant's first important contact with the company. It should be the first step in the process of integrating the interests of a new employee with the service objectives of the organization. The interview therefore affects the problem of morale development.

The Medical Examination

If the applicant's interview is satisfactory, the next step may be a medical examination to determine his physical fitness for the job. Some men who may be suitable for employment may be restricted by the plant physician to certain types of work because of certain physical disabilities. The physical examination is of benefit both to employer and employee. It protects the new employee against the aggravation of any disabilities he may have. It may bring new ones to light, in which case he will be advised to consult his own physician; this may save him from serious trouble later. Labor turnover and compensation claims may be reduced.

Small plants often cannot afford the services of a full-time physician. In such cases, the applicant's examination may have to be postponed until

such time as the physician is in attendance. There should be regular hours for examination each day. The examining physician usually enters a summary of the examination on the application blank. The applicant returns with it to the interviewer.

Selection Tests for Employment

Some plants also give certain psychological or trade tests to those applicants who pass their physical examination. A summary of these results also may be entered on the application blank. Such tests usually indicate the probability that the applicant has certain characteristics or abilities that are necessary for success on the job. He must have them in some minimum degree, at least. Further consideration of these tests will be given in connection with personnel research. The blank is returned to the employment department, in the meantime, for further processing.

The Employment Decision

Much of the procedure so far has had to do with the collection of information concerning a candidate for a job vacancy. The objective has been a factual basis for a sound employment decision. The first decision is made by the interviewer or the employment manager. The employment procedure usually stops if the interviewer decides on the basis of the facts that the particular candidate is not suitable. The employment department performs a staff service, however. The final decision to hire therefore should rest with the department head under whom the man will work. The interviewer should send the job candidate to the department with an escort and some form of an introduction slip. If the department head is satisfied with the candidate, after talking with him, he can so indicate to the interviewer by initialing the introduction slip or by other suitable means. Otherwise, the employment procedure stops at this point, unless the applicant can be considered for another vacancy. There are a number of advantages in this policy. It tends to strengthen the position of the department head and therefore to gain his support and coöperation. Moreover, he is more familiar with the technique of the job; hence his opinion of the applicant is correspondingly valuable. Finally, no executive can be held responsible for results from an organization whose personnel has been selected by someone else.

Closure of the Employment Procedure

The applicant has now been examined carefully from several angles. If he has been found to be satisfactory the interviewer may make out a notice of hiring, like that in Fig. 23.5. It is forwarded with the other

F-1029

STATUS CHANGE HOURLY RATE EMPLOYEES

Printed in U. S. A.

Factory________ Date________

Name________ Address________

Payroll No. and Department________ Job Title________

☐ EMPLOYMENT — Time Employed________ AM/PM Rate________ Soc. Sec. Acct. No.________

Date of Birth________ Sex M___ F___ Foreman Receiving________

☐ TRANSFER — To Department________ New Payroll No.________

New Job Title________ Foreman Receiving________

☐ RATE CHANGE — Date Last Rate Change________ Old Rate________ New Rate________

☐ LEAVE OF ABSENCE — Ending Date________ D. B. dues to be paid in advance: Yes____ No____ ☐ TERMINATION

Reason for Change________

Date Effective________ Participant in: D. B.____ Paid Thru________ P. S. D.____ S. P.____ Pension____

Last Day Worked________ ________ Originator ________ Service Department Approval

________ Payroll Entry Date ________ By ________ Approved (Supervisor) ________ Authorized (Superintendent)

Fig. 23.5. Notice of Hiring and Status Change. (Courtesy, Proctor & Gamble.)

employment papers to the personnel division. This notice conveys the essential information relating to the job, the employee's name and number, his starting rate, and other data necessary for payroll or other record purposes. If he does not go to work at once, the notice should state when he is to report. Several copies of such a notice may be originated. The original goes to the payroll department, and the duplicate is sent to the department head under whom the new employee will work. The triplicate should be retained in the division office, together with the requisition and specification. The record clerks should clear the transaction in the labor journal and make the necessary entries in such other records as may be set up for the employee. Copies may also be sent to the medical and labor relations departments to enable them to complete their records and follow-up on the new employee. A copy is sometimes given to the employee; this serves as a gate pass until he receives his regular pass or badge.

The Personal Service Record

A history card or personal service record is usually made out for the employee. It is intended to give a brief but sufficiently complete history of his connection with the company. As such, it is a valuable aid in promotion, wage adjustments, and transfers, and in handling the individual labor relations problems that constantly arise. A file of these cards becomes a record of the company's human inventories. The example in Fig. 23.4 serves both as an application blank and a service record. This form is designed for visible index filing, as shown in Fig. 23.6. The form in Fig. 23.7 also is a part of the employee's record. It is made out by the personnel office of the company, but it is maintained by the payroll department. Other records are necessary for income tax and social security purposes. Union contracts may contain a clause to the effect that "promotions and transfers shall be based on seniority, other things being equal." The "other things" are merit of course. It may be necessary, in a union shop, to promote on the basis of seniority, unless we have adequate service records.

Most concerns do not keep elaborate personal service records for operative employees, however. The great majority of the employees are not potential candidates for advancement because they lack the necessary leadership qualifications, education, training, etc. On the other hand, complete separate service records may be kept for executives and key employees. The successful, growing concern will find it an advantage to start such a record as soon as an employee shows any potentialities for

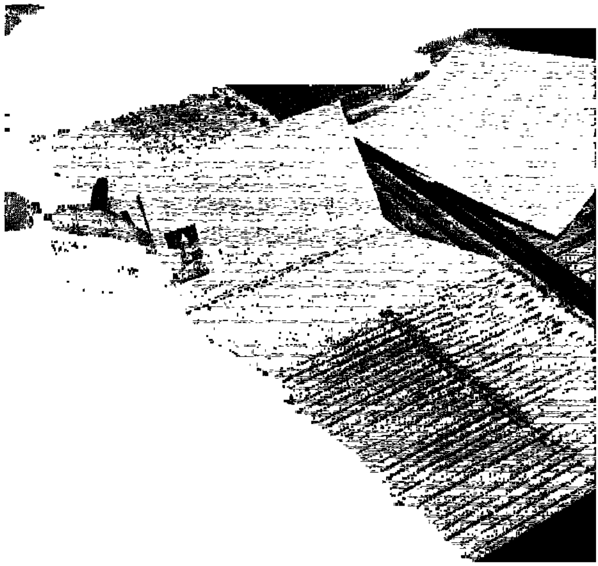


Fig. 23.6. Visible Index File of Employee Service Records. (Courtesy, Remington Rand Div., Sperry Rand Corp.)

advancement. Such a concern seldom has too many good men. It will probably urge him to avail himself of all company educational and training opportunities that will aid his development.

The Induction of the New Worker into the Organization

The function of procuring a new employee terminates and labor relations work begins with his induction into the organization. The labor relations department should receive a copy of the notice of hiring. The manner in which induction is handled may greatly affect the employee's attitude toward the company and its executives. It may determine the length of time that he stays with the organization. The problem concerns primarily the employee's adjustment to the organization and the effect on morale.

In some plants, an employment office messenger takes the new employee to his department. He gives the department head a memorandum or notice of hiring. The foreman, if it is a shop department, takes the employee to the machine that he is to operate, gives him whatever instructions may be necessary, and tells him to go to work. The new employee may know none of the men working around him. He has little knowledge of the company or its methods beyond what is necessary for

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EMPLOYMENT RECORD

Name of Employee Robert J. Jones Time Clock No. 5 Badge No. 376

Date of Employment May 21, 1951

Date	Job Code No	JOB NAME	Rate Range	Class	Grade	Dept No.	Shift	Hourly Rate	REMARKS
5-21-51	2-61A	Hand Trucker	.98 - 1.20			2	2	1.05	
7-9-51	2-11	Drill Press - Sgle. Spdle.	1.00 - 1.22			2	1	1.05	
9-3-51	2-11	" " " "	1.00 - 1.22			2	1	1.11	
10-29-51	2-8	Mult. Spdl. Drill Press	1.04 - 1.27			2	2	1.11	
11-26-51	2-8	" " " "	1.04 - 1.27			2	2	1.17	
3-3-52	2-8	" " " "	1.04 - 1.27			2	2	1.22	
3-24-52	2-8	" " " "	1.04 - 1.27			2	2	1.27	
10-13-52	209	Drill Press Opr. Sgl. or Mult. Spdl.	1.45 - 1.59			2	2	1.66	
2-23-53	208	Drill Press Opr. (Radial)	1.57 - 1.73			2	1	1.66	
5-18-53	208	" " " "	1.57 - 1.73			2	1	1.71	
8-17-53	208	" " " "	1.57 - 1.73			2	1	1.73	
10-5-53	208	" " " "	1.64 - 1.80			2	1	1.80	
11-11-53	209	Drill Press Opr. Sgl. or Mult. Spdl.	1.51 - 1.66			2	2	1.73	
12-7-53	230	Trucker, Hand	1.39 - 1.53			2	1	1.66	
3-1-54	3903	Drill Press Opr. Sgl. or Mult. Spdl.	1.51 - 1.66			39	1	1.73	
1-3-55	3903	" " " " " "	1.54 - 1.69			39	1	1.76	
8-16-55	208	Drill Press Opr. (Radial)	1.67 - 1.83			2	2	1.83	
8-23-55	203	Boring Mill Opr. Vertical	1.81 - 1.99			2	1	1.83	
10-1-55	203	" " " "	1.89 - 2.07			2	1	1.91	
11-21-55	203	" " " "	1.89 - 2.07			2	1	1.96	

Fig. 23.7. Employee Service Record, Showing Rate Changes and Transfers. (Courtesy, Jaeger Machine Co.)

him to do his work satisfactorily. He is given little opportunity to become acquainted with the plant and its products. Under such conditions, he can hardly be expected to have more than a payroll interest in his job. His first impressions are cold and colorless. Except for the foreman's occasional visits to supervise his work and give additional instructions, he has been forgotten, apparently, by the management. He may miss his former familiar surroundings. He may become hypercritical of the conditions on his new job for such reasons. He becomes dissatisfied easily and sometimes quits before he has become accustomed to his new environment. In most industries, the greatest turnover takes place among employees who have been with the company less than 1 year; within this group, the turnover is greatest among those who have been employed less than 6 months. The turnover may of course be heavy for other reasons, such as poor training, poor selection for the job, etc. The above conditions are not typical of progressive concerns today, however. The foreman in such a concern probably will introduce the new man to the men on the machines near his own. In the course of the first few weeks, someone from the labor relations division will talk with him on the job to see whether he is making good progress and is satisfied with his work. The intent is to make the new employee feel that he belongs to an organization that is interested in him, that he is not regarded merely as a productive unit in a large organization.

Most plants also give the new employee a book of rules which states employment regulations and the company's personnel policy. The company's aims and ideals are also stated. There may be some discussion of the products, manufacturing methods, and their relations to his interests. Among the topics usually treated are standard hours of work, holidays, vacations with pay, various other fringe benefit plans, payments for overtime, the employees' credit union, absence and tardiness regulations, educational opportunities in the plant, quits and dismissals, etc.

New employees often are skeptical of the degree of sincerity behind such statements. They may give their booklets only a cursory examination before throwing them away. For this reason some concerns require a new employee to sign a card at the end of his first week or two, stating that he has received and read his rule book. This is done to insure that he will acquire at least some knowledge of the company and its policies. We cannot publish our way into a condition of good organizational morale, of course. The communication of ideas and information concerning company organization, operations and policies is necessary from an

effective integration of interests, on the other hand. Executive leadership, nevertheless, is the most important single factor in the morale development in any organization. Responsibility for the induction of the new employee must rest finally on his departmental executives.

One of the biggest problems in industry is the employee's lack of knowledge of the organization and of the various processes required in manufacturing the product on which he work. He usually knows little of the operations that precede and follow his own. With such a restricted view of his job, he can hardly be expected to have a real interest in it, except that stimulated by a wage incentive; under such conditions almost any job becomes monotonous. This is particularly serious in the case of the new employee. Some concerns provide lectures, illustrated with motion pictures, to acquaint the new men with the different products and operations. The new employee may also be given general information concerning the principal departments, their work, and the relationships between them. Sometimes they are taken on a tour of the plant. In recent years, several large concerns have held an annual open house for their employees and the public, at which the whole organization and its work is put on display. This helps also to weld the newcomer into the organization. The employee who has little interest in his job is not likely to have much interest in his organization. He is not likely to have much confidence in the purposes of the organization when he has little confidence in his supervisor. It is the departmental executives, again, who will weld the new employee into the organization. The activities of an industrial relations staff are supporting services for operative executives, in so far as the induction of a new operative employee is concerned. These services make some very important contributions, of course.

Promotion and Transfer

Vacancies above the unskilled labor level should be filled by promotion or transfer, as far as possible. When properly planned, these functions result in greater organizational flexibility, stability, and effectiveness. However, these promotions also involve certain problems of morale. To use promotion and transfer properly requires certain criteria for whose development extensive investigation and study are often necessary. Therefore they will be discussed again when labor relations and personnel research are discussed.

An understanding of the terms transfer and promotion is necessary before they can be discussed. A transfer is a change in job assignment at

the same general service level. A promotion is any change in status that improves the employee's economic or social position in the organization. However, a change may involve both transfer and promotion, as in the case of an employee's transfer to another operative job paying a higher hourly rate. There are 3 kinds of promotion: (1) A promotion in position is a change in status that advances the employee to a higher level of responsibility and authority, either operative or managerial. (2) A promotion in pay is one that increases his base rate of remuneration. (3) A promotion in privilege is a change in status that increases the satisfactions that he can enjoy in connection with his work, other than those which result directly from improvements in position or pay. This last deals chiefly with the intangible values. These values are now recognized as being quite as important in many cases as the more tangible material values that have to do with wages, hours, and the physical conditions of work. For example, the privilege of choosing their runs is often granted to bus drivers in the order of their seniority.

A policy of promotion in position implies that vacancies in the permanent organization will be filled from a lower eligible position in the hierarchy of jobs; and that as far as possible there will be a step-up all along the line of promotion. A plan for promotion requires comparable measures of ability, such as tardiness and absence records, production or efficiency records, ratings by superiors on a standard rating scale, intelligence ratings, and other service records. Such facts may be necessary because of union insistence that promotion be made on the basis of seniority, except when superior merit can be shown. It requires also that logical lines of promotion and definite procedures be developed. The principal phases of a promotion procedure have been noted previously, in connection with employment.

In many concerns only one or more key employees within a department will be considered. There may be other employees in other departments who are more entitled to advancement. Their promotion may benefit the company more. In a modern manufacturing concern, jobs are usually classified on the basis of occupations and general service levels; the larger the concern the more likely this is to be true. Each job or occupation has a number. Several employees may do the same type of work within a department, and the same general occupation may be found in several departments. The job specification for a vacancy should list the jobs from which a promotion can be made. This implies some previous research in order to work out all the promotional relationships of each job. These relationships should be correlated in a definite promotion plan,

and may be shown graphically in a promotion chart such as that in Fig. 28.5.

When the interviewer receives the requisition and specification, he may consult an occupational cross file which contains a card for every employee who does such work anywhere in the company. The cards of those who merit promotion are flagged; thus he can select easily and quickly several promising candidates, some of whom may work in other departments than the one in which the vacancy has occurred. An inspection of their service records enables him to weed out most of them at once as unsuitable for the particular promotion. It has been noted previously that information on the application blank and service record may be key-punched into tabulating cards. The initial sorting of potential candidates can then be done mechanically or electronically.[2] These candidates are called to the employment office for an interview. Those who look suitable are sent to the department head for interview, in accordance with the employment procedure. He cannot be forced to take someone he does not want, of course. In the event of a serious difference of opinion, the matter will probably be adjusted by a conference between a representative of the personnel division, the department head, and his line superior.

If the candidate is satisfactory, the employment office originates a notice of transfer or promotion, similar to that used for hiring, which will be approved by the line superior. Copies should go to the personnel records section, the payroll department, the department heads affected, and such other individuals as are concerned. In most cases, the employee is notified personally by his superior. This policy strengthens the leadership position of the particular executive. Many concerns publish promotions in the plant paper.

Each concern's procedure will of course differ from the methods of other concerns somewhat. However, any good procedure will attempt to assure equality of opportunity for advancement, and conversely, to minimize nepotism, favoritism, and organization politics. This procedure will see that the employee gets the satisfaction that comes from public recognition of success, thus enabling the company to make the best use of its employees' abilities. It will contribute accordingly to greater organization stability and effectiveness. Without encroaching on their

[2] Employees are entitled to an accurate, general but nontechnical understanding of the promotional procedure. Such an explanation was published by General Mills for its employees in the July, 1954, issue of its house organ, *The Modern Mill Wheel*. The reference article explains the use of IBM cards in the company's promotional procedure.

responsibility and authority, it will relieve the line executives of as much of the detail of promotion as is compatible with the retention of their leadership position.

As Fig. 23.8 suggests, a promotion in position is not always accompanied immediately by a raise in pay. Despite the records, tests, interviews, training, etc., his superiors cannot be entirely certain that the new man will

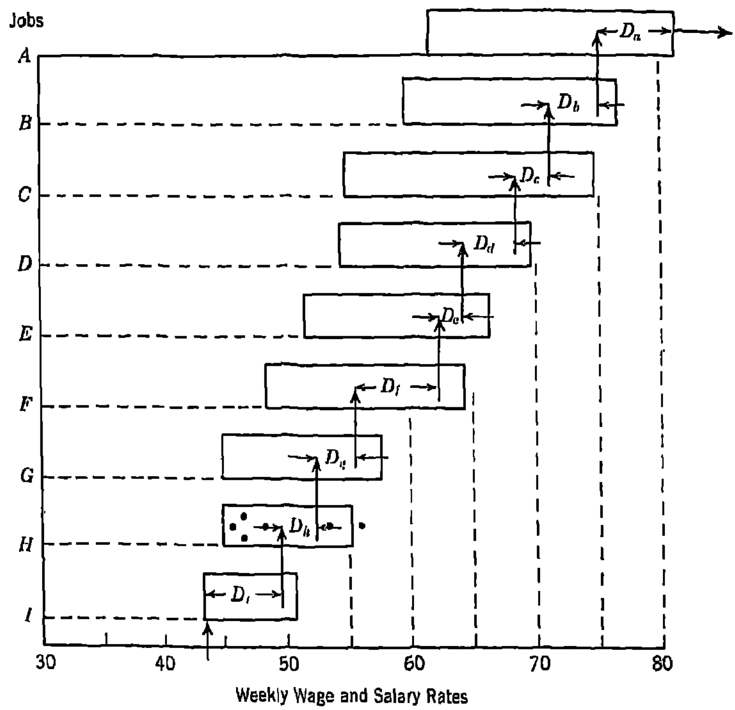

Fig. 23.8. Wage and Salary Control Chart.

make good; they can only establish a high degree of probability that he will. At first, however, he is still on trial. Even if he knew as much about the job as his predecessor—which is most unlikely—it would be unwise to give him the top rate immediately, for this would put his monetary future behind him for quite some time.

Similarly, a transfer does not necessarily carry a raise in pay. It may be made to provide another opportunity for a man who is failing on his present job. It may be made to broaden his experience, thus making for greater organization flexibility and possibly paving the way for his advancement in position. Transfers are also often made to balance man

power between departments. An employee may ask to be transferred to work more in line with his interests.

Wage and Salary Administration

Promotion in pay was defined above as any change of status that increases the individual's base rate of remuneration. The introduction of an incentive payment plan may increase earnings, but usually involves no change in base rate or status. The two most important phases of the problem of wage and salary control have to do with base earnings and incentive earnings. The latter are the amounts above base earnings, exclusive of any overtime, that are paid for some type of superior performance, in terms of increased quantity, quality, etc. The personnel division is not directly concerned with them, except as they affect morale. It may keep a record of employee earnings.

Base earnings result from the application of a base hourly rate of compensation to the hours of time served by an employee during a period. This rate should be related to the prevailing rate of wages in the community and the industry for the particular class of work. When it is set by collective bargaining, it is determined by agreement between the management and representatives of the employees. Operative employees are usually paid for each hour of work at their base hourly rate. They may also receive incentive earnings, in addition. Even the piece-rate workers in most modern plants are paid at their base hourly rate for idle time due to causes over which they have no control. A salary is a form of payment which does not vary directly with the amount of time worked during a given period or the quantity of work produced per unit of time. The base salary rate is the amount of compensation for the period, exclusive of any incentive payments; it may be set up on a weekly, monthly, or annual basis. A salary is the usual form of compensation for an executive. His work is largely mental, and his contribution is often intangible. It is difficult to measure it objectively except over an extended period of time. In a sense, he has no hours of work because of his leadership responsibilities. An urgent problem may require him to work evenings or week ends.

Recommendations for rate increases may result from an employee's request to his superior, or the action of a wage and salary committee. In some concerns, such a committee periodically reviews the rates of executives and key operatives. A rate recommendation must come from a department head. It must be sent to the wage and salary department on a prescribed form and carry his line superior's approval. This department

is shown in Fig. 22.1 and 22.2. When rate reviews are made periodically, this office probably will originate the rate-change form for all who come up for consideration at that time. The actual decision as to the increase usually rests with the employee's superior officer. The wage and salary administration department and committee render a staff service of information and advice. They have recourse to higher line authority in case of disagreement with the departmental or divisional executive under whom the employee works.

These requests for rate adjustments affect both the morale of the employee and the expense of running the company. These must be controlled, therefore, and there must be a definite wage promotion plan on which control can rest. It should provide definite criteria that will permit the application of policies governing promotion in pay. The usual objectives in developing such a plan are: (1) the elimination of injustices in making wage and salary adjustments; (2) the stimulation of application to the job, length of service, better morale, etc., that results from an equitable handling of the problem; (3) economy in wage and salary costs; (4) the motivation of employees to improve themselves in their performances; (5) the provision of facts for collective bargaining purposes.

In the days when the foreman hired his own men and set their starting rates, he sometimes took advantage of their inferior bargaining ability to beat them down to a rate below that to which they were entitled. While this made his wage cost look good, it was not to the company's advantage in the long run. There was usually no rational relation between the starting rates for jobs in the same classification. The foreman was frequently accused of favoritism in granting rate increases. Relatives or friends might be getting more than the job was worth, while others doing the same class of work were getting less. Such injustices created dissatisfaction and unrest. They stimulated the employees to play politics rather than to improve their performance, apply themselves to their jobs more diligently, etc. Conditions were similar on higher organization levels. The mission of the wage and salary administration department is to avoid these difficulties, and accomplish the objectives.

The principal factors in the wage promotion problem are: (1) a definite procedure that will assure the equitable consideration of rate increases, (2) the availability of personal data that will show the employee's merit, in so far as his performance is concerned, (3) a classification of jobs according to organizational service levels, (4) a range between minimum and maximum rates for jobs on the same service level that is adequate to stimulate self-development for the present job, and (5) a differential

between rates on adjacent service levels that will stimulate self-development for promotion to higher responsibilities. The first two factors will not be discussed further, for they have already been given sufficient consideration.

There should be a definite range of pay increases that will permit reasonable recognition of good performance, and at the same time keep wage and salary costs within limits that the company can afford to pay. This problem is illustrated in Fig. 23.8, which shows a control chart for Department X. The minimum rate for job H is $45.00 per week, and the maximum is $55.00. The range of in-grade rate promotion is usually 15 to 30 percent of base. The black dots on the chart are glass-headed pins which show the wage of each employee on this job. If a request for a rate increase comes through for the man who is getting more than the maximum rate, obviously the wage and salary administration department will scrutinize it with extreme care. The man who is getting less than the minimum rate also presents a problem that must be studied carefully. Jobs on standards and incentives do not require an in-grade range of promotion in base rate. The range of increase in production over standard also is about 15 to 30 percent for the average operative who has been properly selected and trained.

Job I starts at approximately $43.50 per week. There is a wage differential of $1.50 per week in the starting rate for this job and job H. This is not sufficient, if there is a promotional relation between the two jobs. A 10 percent differential is usually the minimum that will provide sufficient incentive for self-development for greater responsibilities. Such rate differentials are based on job differentials. These are the differences in the requirements of jobs that affect their relative values. A familiar example is the rate differential between inside and outside carpenter work. Differences in job worth should be determined by job evaluation. This is a method of evaluating the basic work factors in a job, such as skill, effort, responsibility, working conditions, and their principal subfactors. These will be discussed briefly when the personnel research function is discussed. It is sufficient to note here that a man may advance step by step in the organization, but the magnitude, scope, and importance of his responsibilities usually increase at a faster rate. Promotion in position should stimulate the self-development, interest, and loyalty of the more ambitious and able employees. These employees should be paid fairly and the incentive value of promotion should be retained. The rates for related jobs on different service levels usually range upward from the unskilled labor rate in some geometric progression for this reason.

Personnel Records and Labor Turnover

The passage of the Social Security Act, the Fair Labor Standards Act, and other acts affecting personnel has greatly increased the number of records necessary. This accounts partly for the increased use of mechanical and electronic tabulating equipment for personnel record keeping. Most of the current personnel records are usually kept in the personnel division. These records are important in connection with employment, promotion, transfer, and separation.

Personnel executives have always regarded labor turnover as a serious problem. Those in progressive concerns have devoted a great deal of study to it. The passage of unemployment insurance laws has made it an important problem for every concern. It has necessitated complete records of employment and turnover.

An employee who quits or is discharged usually has to clear through the employment office. He cannot be paid off until he presents a separation notice signed by the employment manager. This assures the employment office an opportunity to interview him before he leaves. It may be possible to transfer him to more congenial work, or to make other adjustments that will save him for the organization. This may contribute to the maintenance of morale and save part of the cost of labor turnover. A minimum turnover is in the interests of both the employer and the employee. Estimates of the average cost to the employer, under normal conditions, range from $100.00 to $400.00 per employee. The cost of executive turnover may be many thousands of dollars per executive. In addition, under the merit-rating provisions of such acts, taxes for unemployment insurance may increase with increased turnover. Some concerns have formulated a policy such as the following, to cut down turnover: a department head has the right to dismiss an employee from his department but not from the company. Separation from the company requires usually the concurrence of the employment manager.

The term "labor turnover" may include all separations from the payroll, regardless of cause. However, some authorities consider that turnover does not occur until replacement takes place. Apparently most personnel executives feel that layoffs should not be regarded as turnover. A complete record of them must be kept, nevertheless, because temporary unemployment may entitle the employee to state compensation if it extends beyond the standard waiting period in the unemployment insurance acts of the particular state. There are two kinds of turnover: natural and unnatural,

or, to use a better terminology, uncontrollable and controllable. The natural or uncontrollable kind results from causes not due to any fault of the company, such as marriage, better business opportunities elsewhere, assumption of civic duties, etc. The unnatural or controllable kind results from causes that can be traced to poor management, such as insufficient training, dissatisfaction with wages, hours, conditions of employment, etc. It is evident that turnover ratios can be computed on several different bases. Such figures have little meaning, therefore, unless the basis on which they are computed is known.

Before any intelligent progress in reducing turnover is possible, facts indicating its causes must be available. One source of such information is the labor turnover record. A separation or layoff notice in most concerns must give in full the executive's reasons for his action. It may also include notes on the final interview with employees who are leaving the company permanently. These separation notices are posted to a labor turnover record by departments and causes of separation. The value of the record depends obviously on obtaining frank, accurate statements of causes by employees who have been released and the executives to whom they reported, which is not always possible.

In order that trends in turnover may be followed better, labor turnover ratios are usually computed monthly, for the company as a whole and for each department. While they may be computed on several different bases, as noted previously, one simple, widely used formula is:

$$T = S/M$$

in which S is the total number of separations for the period, and M is the average number of men on the payroll during the period. In addition, accessions ratios and labor stability ratios may also be computed. The trends of these ratios, comparisons between company and departmental ratios, and analyses of labor turnover records suggest avenues of investigation that may be profitable. Copies of these analyses and reports are sent to the line executives concerned, and to other executives in the personnel division.

PROBLEMS

1. A firm which manufactured a certain type of heating and ventilating unit estimated that each unit required 45 man-hours of work for completion. Based on a policy of manufacturing partially to inventory it planned a production program as follows:

Month	Units	Month	Units
January	3500	July	2800
February	3500	August	3000
March	3000	September	3500
April	2800	October	3800
May	2500	November	3500
June	2500	December	3500

(a) Estimate approximately how many employees of all classes should be needed to carry out the production program. Assume that the relation of total labor hours, both direct and indirect, to production output remains relatively constant.

2. When the foreman in a certain company needs help, he sends a requisition, in duplicate, to the employment department. One copy is filed here as a record of outstanding requisitions. The other is sent to the proper interviewer by way of the records section, where the job specification is attached. The applicant for the job fills out an application blank and is interviewed. If he seems satisfactory, he is given any test that may be necessary for the job. He receives a gate pass, if he passes the tests. He is told how to get to his department, and when to report for work.
   (a) What functions have been omitted in this procedure? What may be the effects of their omission?
   (b) It is possible that some of the omitted functions are being performed by line executives. How can you tell when it is economical to differentiate them for performance by a staff personnel department?
   (c) Have any principles of business procedure been violated?
3. A plant had 964 men on its payroll at the first of the month, and 1160 at its close. The personnel department's records show that 82 men were separated from the payroll during this month. Department 15 had 35 at the beginning of the month and 47 at the end, and 5 separations. There were 42 men in Department 21 on the first, and 50 at the end of the month; there were 2 separations.
   (a) What was the equivalent annual labor turnover for the plant? For Departments 15 and 21, respectively? Have these figures any significance? If so, what? If not, how can they be made significant?
   (b) How would you classify labor turnover ratios as standards? To what organic function of management, and to what phase of it, do they chiefly relate?

CHAPTER 24 •

• Industrial Health and Medical Supervision

The Objectives and Functions of the Medical Department

INDUSTRIAL medicine has been defined by the United States Public Health Service as "the theory and practice of medicine applied to the purpose of preventing and alleviating sickness and injury among industrial workers in order that they may enjoy the benefits of continuous, productive employment." This definition takes in a broad field that is only partially covered in most concerns. Management may have several objectives in providing for industrial medicine. Such service reduces losses from labor turnover and compensation costs. Employee medical disabilities lower production rates and cause irregularities in attendance; medical service increases the employee's earning power. It saves him many medical expenses, whether or not the company has group health insurance. It results in a higher general level of health, which improves the morale of the operative force. Good medical service, when understood by the public, may be a factor of importance in public relations.

Responsibility for the achievement of these objectives rests largely on the medical department of the personnel division. Its principal functions in discharging this responsibility are: (1) the medical examination of applicants or employees, (2) emergency medical service, (3) first-aid training, (4) health extension service, (5) plant sanitation, (6) health education, and (7) medical supervision. Because of the extremely technical nature of its work, the medical department may have a highly functionalized relationship with other units of the company.

The medical manager, or plant physician, reports directly to the personnel director. This relationship is shown in Fig. 22.1 and 22.2. It suggests the distinction that must be drawn frequently between a technical knowledge and an administrative knowledge of a function. It is seldom that a personnel director is a trained, experienced physician. This director cannot be expected to have a technical knowledge and understanding of problems

in the field of industrial medicine. He is accountable to his line superior, nevertheless, for an effective, economical performance of all functions under his command. This merely requires a sound but general understanding of the major problems of the medical department, and the principal factors that affect them. The personnel director must have such an understanding to enable him to set up the objectives of the medical department, with the advice of his medical manager. The director must formulate policies that will assure the coördination of the medical function with other line and staff activities. The economy of medical operations can be controlled through the application of appropriate staff/line ratios of personnel and expense, without a technical knowledge of medicine. This situation illustrates the leadership problem of many line executives who have a general management responsibility for some technical staff functions. A complete differentiation of administrative management and operative management functions should be made in the case of highly technical staff departments. The responsibility and authority for operative management and operative performance should be delegated as completely as possible to the technical staff executive who is immediately in charge of the function. His line superior usually is not capable of exercising more than an administrative control of technical staff operations.

The Examination of Applicants and Employees

The medical examination of applicants gives greater assurance that their physical capacities will meet the requirements of the job. It guards against the introduction of communicable diseases that might endanger the workers' health. It records any compensable disabilities received on previous jobs, thus protecting the company against unjust claims under state compensation laws or suits at common law. The physical condition of the applicant is usually recorded in great detail on his medical examination blank.

The percentage of applicants refused employment because of physical disabilities is very small. Most of them either have no disabilities or are debarred only from specific classes of work; and in the latter case they are given valuable information regarding their disability that may aid them in removing it. It is obviously unwise to employ a man in the first stages of tuberculosis for a job in the grinding room, where the air is filled with fine emery dust. Although gas masks and air conditioning will protect the worker in normal health, they cannot completely remove all foreign matter from the air. It is equally obvious that no employee should

be permitted to bring into the plant a communicable disease that may menace the health of his fellow workers. In some jobs, lack of physical capacity may cause accidents which endanger the lives of other workmen. For such reasons, a refusal to take a physical examination eliminates an applicant from further consideration in most concerns today.

Some companies periodically examine all their employees. An applicant may be in perfect health at the time of employment, but 6 months later his physical condition may have changed materially, regardless of whether the job presents dangerous health hazards. It is to uncover such cases that the medical department conducts periodic surveys of the general health of the working force. Such an examination may be required by law for food handlers or others whose work affects the health of the public. Some concerns do not follow this practice. They require instead that employees be given a medical examination before being promoted or transferred to a new job, or before returning to work after a period of illness. Such companies may also require a periodic physical examination for the executive but not the operative employees. This policy is a recognition of the greater importance of the leadership function. Physical examinations are fact-finding functions which bring to light information concerning the health of individuals and groups within the organization. Such facts are necesasry for the achievement of the medical department's objectives.

Emergency and Other Medical Service

The quality and amount of medical service provided for employees varies greatly between concerns. The development of this service depends on such factors as state requirements, the size of the company, the management's attitude toward personnel work, the degree of hazard in the various jobs, the relation of operative work to the public health, and the company's economic position in the community. The service ranges from providing conveniently located first-aid kits and the part-time services of a neighboring physician, to the completely-equipped hospitals maintained by some of the larger corporations. The problem has two chief phases: emergency medical service, and medical treatment for employees.

Industry tends to be hazardous. The degree of hazard varies greatly between industries. The amount spent for medical facilities tends to vary accordingly. The duration of the disability caused by an accident and the seriousness of its consequences may depend on the promptness and thoroughness with which the injury is treated. Every company is under the ob-

ligation to see that its employees' interests are protected in these respects. Most concerns require every employee to report immediately to the company hospital if he suffers any cut or abrasion that breaks the skin. A small scratch can result in serious infection. The injured man's superior has no discretion in the matter, usually. He must issue the necessary hospital pass. The employee receives pay for the time thus taken from his job. Such considerations as the effect on employee morale, compensation costs, interference with production, etc., make it to the advantage of the management to return him, completely recovered, to the job in the shortest possible time. The management's motives in supplying adequate medical service are those of intelligent selfishness, as well as the desire to treat its employees fairly.

Employees may also be treated for minor ailments, particularly those which develop on the job. Some concerns go far beyond this. They provide a certain amount of free dental service and, on the recommendation of the plant physician, free eye, ear, nose, or throat examinations. Common colds cost industry and its employees many millions of dollars annually. The treatment of such minor ailments therefore is an important part of the work of the medical department. The amount of service that can be provided tends to increase with the size and financial strength of the company. A concern which is the dominant economic factor in the community may find it necesary to supply certain public health services. It has been pointed out that, when there is a direct relation between the worker's health and the public health, the medical department usually has to give closer medical supervision to employees. The extent to which all these services are supplied beyond the legal minimum depends on the intelligence and vision of the management. As a rule, however, the policy is not to compete with the local medical profession; hence employees requiring extensive treatment are usually referred to their family physician.

First-Aid Training

The training of first-aid crews in connection with emergency medical service may be part of the medical department's work. When first-aid work has been organized formally, it may include training under the company doctors, lectures, demonstrations, and drills. As a rule, no employee can be appointed to a first-aid crew until the plant physician has certified that he is competent for this work. In order to stimulate interest, some companies hold annual competitive drills for their first-aid crews.

Health Extension Services

Some plants employ visiting nurses in connection with the maintenance of employee health. After an employee has been absent for a certain length of time, the visiting nurse goes to his home to find out the cause of his absence. In case of illness, she may give such assistance as may be necessary. She may also be available to the employees or their families on request.

In addition to being skilled in her profession, the visiting nurse should be tactful, have a pleasing personality, and be imbued with a genuine desire to be of service. After she has gained the confidence of the employee and his family, she may be able to help in such matters as the making of family budgets, dietetics, the care of children, and similar family problems.

These services, however, should not become paternalistic. Except in the case of continued absence, the visiting nurse should not visit an employee's home unless requested. She should demonstrate the value of her services to the employees to the end that requests for her help will be spontaneous. The economic justification of such services rests on the fact that they tend to improve the health and morale of the workers through improving their home conditions. These services tend as a result to increase their attendance regularity on the job and their productive efficiency. These services are usually more practicable in nonurban areas where medical and social services may not be adequate.

Plant Sanitation

An important aspect of the plant physician's work is plant sanitation. He should educate the employees on matters of general sanitation, and safeguard their health by inspection, periodically, the sanitary conditions in the plant. In some cases, this may involve a bacteriological test of the drinking water, installation of sanitary drinking fountains and proper locker room and toilet facilities, prevention of occupational diseases through the introduction of proper safegaurds, inspection of the company's restaurants, inspection of its sewage and garbage disposal systems, removal of dust and fumes, etc.

Health Education

An employee, like almost everyone, may not take the initiative in safeguarding his health until it demands attention. The medical department consequently may devote considerable attention to general health educa-

tion. It may use such means as posters on the bulletin boards, enclosures in pay envelopes, and articles in the company paper to bring simple health rules to the attention of the employees, and to urge compliance with them. This health department also coöperates with the safety and compensation section in its work on safety education. It attempts by various means to get employees to make use of medical facilities.

Medical Supervision

Despite the company's medical policies and educational activities, the employees may not make the use of its medical facilities that they should. Consequently some degree of medical supervision becomes desirable. A medical record, similar to that shown in Fig. 24.1, may be kept for each employee who comes to the office for treatment. In addition, the department has the results of each employee's medical examination. It should also have a copy of the absence and tardiness reports so that it can follow up cases of continued absence. The department may also receive reports from the production control department showing the productive efficiency of the various departments and individuals; the start of an epidemic of colds, for example, often shows in the production record. Employees whose production tends to decline may be suffering from some physical or mental disability without realizing it. A few concerns employ a psychiatrist to handle the latter cases.

Cost of Medical Service

Many concerns spend large sums for plant medical service. The annual cost per employee varies greatly between concerns. Medical service usually costs the food and mining industries much more than it does the average industry, because the former is directly related to the public health, and the latter is hazardous. Other causes of this variation have been noted previously.

Medical service is not provided with the idea of making a profit; certain savings do result. The more important have been discussed. To get a more concrete conception of them, a brief analysis of the savings that may follow the medical examination of applicants is necessary. A conservative estimate of the result of this examination is that 5 percent of the applicants are rejected, 35 percent are found to have partial disabilities, and approximately 60 percent are physically able to do any work for which they are competent. We shall assume that in a concern which has no personnel service, only 10 percent of those having partial disabilities will quit or be dismissed because of poor physical adjustment to their jobs—

F 1400 Sept. 50

PHYSICAL EXAMINATION RECORD

Factory, Mill, District or
Branch .... Date .... Name ....

PERSONAL HISTORY

Date of Birth .... Sex .... Marital Status: S M W D Military Service: Yes ☐ No ☐

Position applied for .... Department ....

Last previous position .... Employer ....

Second last previous position .... Employer ....

How much insurance do you carry? .... *Ever rejected for life insurance?* ....

FAMILY HISTORY

Father: Alive .... Age .... Deceased .... Cause .... Age at death ....

Mother: Alive .... Age .... Deceased .... Cause .... Age at death ....

MEDICAL HISTORY—Check (√) if negative or give year of occurrence. Explain below.

Asthma		Hemorrhoids		Ever operated on?	
Backache		Indigestion		Ever been injured?	
Blood Spitting		Jaundice		Ever a patient in hospital?	
Bronchitis		Joint Pains		Ever a patient in Institution?	
Cancer or Tumor		Kidney Trouble		Ever injured at work?	
Constipation		Malaria		Ever rejected for employment?	
Diabetes		Mental Disease		Ever rejected for military?	
Dysentery		Nervous Breakdown		Ever rejected for health insurance?	
Eye Condition		Neuritis		Your most recent illness	
Epilepsy		Pleurisy		Days lost past year	
Fainting Spells		Pneumonia		Vaccination—Small Pox	
Frequent Colds		Rheumatic Fever		Typhoid	
Gall Stones		Running Ear		Other	
Gonorrhea		Sinus Trouble		Female—Menses Regular	
Hay Fever		Skin Condition		Date Last Menses	
Headaches		Stomach Ulcer		Go to bed because of pain?	
Heart Trouble		Syphilis		Lose time from work?	
Blood in Urine		Tuberculosis			

Any other disease or injury? ....

I certify my answers to the above to be true, and I agree that details of this record may be disclosed to my employer

Signed ....

Remarks: ....

(Note: Space is provided on the back of this form for the entry of detailed medical information, when the employee is examined by a company physician.)

Fig. 24.1. An Employee's Medical Record. (Courtesy, Proctor & Gamble.)

this is another conservative estimate. Therefore the medical examination of applicants can be credited only with preventing 8.5 percent of the turnover that there would be without it. The annual labor turnover in this concern is 120 percent. A conservative estimate of average turnover cost would be \$100.00 per employee. Assuming that a reasonable annual cost per employee for medical service would be \$10.00 per employee, and that the company has 1000 employees on its payrolls,[1] then,

[1] Ratios and cost figures vary between companies, industries, and positions in the business cycle. The figures assumed for the above example are believed to be typical of conditions since World War II.

Annual turnover is (1000 employees × 1.20)	1200 men
The turnover due to lack of medical examination is (1200 men × 0.085)	102
The cost of this turnover is (102 men × \$100.00 per employee)	\$ 10,200.00
The total cost of medical service is (1000 men × \$10.00/employee/yr)	\$ 10,000.00
Saving	\$ 200.00

It will be noted that the entire cost of medical service has been loaded on the medical examination of applicants, in the above analysis. There are other functions of the medical department that may return an expense saving to the company, in addition to the satisfaction of making a contribution to the employee's well-being. No account has been taken, either, of the expense saving for the employee.

CHAPTER 25

Labor Relations and Morale

The Field of Labor Relations

LABOR relations includes those problems that grow out of conflicts of personal and organizational interests, either real or apparent, within the business enterprise. The term, when used broadly, includes executive relations as well as operative relations. Labor relations suggests to most people, however, the relations between the personal interests of operative employees, the service objectives of the business organization that employs these operatives, and the personal interests of the owners of the business. The term will be used in the latter sense.

Conflicts of interests between a business organization and its operative employees may result in strikes. Such conflicts may affect the public interest greatly. They may present, accordingly, community and national problems in public relations. A serious deterioration of morale may develop when there is no open breakdown in labor relations. The personnel and labor relations functions, in some concerns, are headed by the same staff executive, for this reason. He reports directly to the president or the executive vice president of the company, as shown in Fig. 11.2. His relations with personnel executives on lower echelons are strictly staff, of course.

Labor relations management then may be defined as that phase of management which is concerned with the integration of interests in the concern. Its immediate objective, therefore, is good organizational morale. Its ultimate objectives are the effects of good morale, such as willing coöperation, loyalty, good discipline, etc.—values which affect greatly the economy and effectiveness of the work of the operative force, and its executive leadership. There have been serious breakdowns of morale in many industrial concerns in recent years. Management has been giving increasing thought and study to its development and maintenance, in consequence.

The Labor Relations Department

Responsibility for the proper solution of labor relations problems rests primarily with the line executive organization. It provides the immediate leadership for the employees in their work. The company's policies and procedures are applied by operative executives to the performance and control of operative work. Departmental management, either line or staff, is largely supervisory management. Supervisory executives have a direct influence on the attitudes of the employees because of their continuous face-to-face contacts with them. Foreman-training programs give much attention to departmental leadership problems for this reason. Labor relations problems, on the other hand, usually require careful, delicate handling when they get beyond the departmental level. Background, training, and experience may be needed which even the higher administrative executives may not have. The best evidence is the use of labor relations consultants and lawyers by many companies. Many large concerns have set up labor relations departments. Such a department is usually organized as a component of the personnel division. It is a technical staff element, reporting to the principal personnel executive, as shown in Figs. 22.1 and 22.2. The functions assigned to a labor relations department vary between concerns. These include, usually, those activities that enter into the integration of personal and organization interests. These functions may concern the investigation and adjustment of disciplinary problems, staff assistance in joint negotiations with union representatives, the development of an understanding of management problems throughout the organization, advice on public relations problems that affect labor relations, and similar problems.

The Nature and Importance of Morale

The term "morale" refers to a mental condition of individuals and groups.[1] Morale may exist in an infinite number of degrees between the extremes of completely positive and completely negative morale. Organizational morale conditions the attitudes of members toward the organization's objectives, activities, and leadership. Good morale induces the members to make reasonable temporary subordinations of their personal interests to the advancement of the organization's service objectives. They must have some assurances, however, that they will regain, in the near future, a greater amount of personal values. It is not always necessary that

[1] Funk and Wagnall's *New Standard Dictionary* defines it as: "A state of mind with reference to confidence, courage, zeal, and the like, especially of a number of persons associated in some enterprise."

they be the same kind as those that were sacrificed. Otherwise it is unlikely that a subordination of personal objectives will be made voluntarily.[2] Good organizational morale depends on intelligent selfishness on the part of all members of the organization, both executive and operative.

These personal objectives may include any desired values, either tangible or intangible. Operative employees, for example, may want a feeling of confidence in their executive leadership, of belonging to a winning team, of worth-whileness growing out of constructive participation in a worth-while mission, or other intangible values.[3] These are often quite as important as good wages, reasonable hours of work, good working conditions, and other material values that are derived from employment. Surveys have shown this to be true when employees regard such tangible rewards as fair and equitable. Any values must be provided in the immediate rather than the distant future. The average employee has a short-run viewpoint, because he is needy, lacks vision, or for other reasons. The consumer's dollar is the primary source of all material values, nevertheless. The price of continued patronage, in a competitive industrial economy, is the continuous provision of competitive customer values. This means that goods and services must be provided continuously, which are equal to or better than competitors', and at a competitive price. The primacy of the service objective is a practical management principle for these reasons. The accomplishment of this mission usually requires considerable long-range planning. This application involves necessarily some conflict between the short-run viewpoint of operative employees and the long-run viewpoint of general administrative executives. This is particularly true in large organizations.

Some temporary sacrifice of personal interests in the achievement of common service objectives is a requisite for the development of morale. It is necessary for the satisfaction of creative urges. Morale aids in the development of a feeling of belonging, and tends to produce a feeling of worth-whileness. A willingness to make such a sacrifice is also a test of

[2] An involuntary subordination of interests is not necessarily an evidence of good morale. The employees of an Indiana furniture factory have volunteered to work for one month without pay, at the time that this is being written. The plant has been closed down because of financial difficulties. (See the *Wall Street Journal* of April 4, 1956.) Involuntary subordinations are usually motivated by fear.

[3] Mr. George J. Meyers Jr., for example, has said: "Our employees, without our knowing it, and without perhaps knowing it themselves, wanted leadership they could respect, convictions they could believe in, and we were giving them neither. . . . Since then we have put together a statement of industrial philosophy for the Company." It is his feeling that the company's labor-management relations have been improved greatly as a result. *Management Newsletter*, June 1953, The National Foremen's Institute.

morale. It therefore depends on confidence in the integrity and ability of the organization's executive leadership.

Anything which affects the relations between the personal objectives of individuals and groups and the service objectives of the organization, may act as a morale depressant or stimulant. In consequence, the number of possible morale factors is almost infinite. There may be a large number in a particular problem. These may differ in each successive phase. The complexity and intangible nature of the problem of morale explain some of the difficulties in handling it properly.

The Objectives of Morale Development

The values which are contributed to organizational effectiveness by good morale are vital for business success. This has been recognized by most great business leaders. These values are the objectives of the morale-building process. The more important objectives are willing coöperation, loyalty to the organization and its leadership, good discipline, organizational stamina, organizational pride, interest in the job and the company, and intelligent initiative.

Some recent articles have noted an apparent lack of correlation between high morale and high productivity. There are many factors that condition productivity. Machines, for example, have been taking over more and more of the work of production. Some morale surveys have measured chiefly job satisfaction. This is not necessarily synonomous with organizational morale. It may represent, for example, merely satisfaction with a condition under which more money for working fewer hours with less effort is obtained. The attitude of the workers toward productivity may be a factor. An employee may suffer social ostracism, for example, if he becomes a high producer and a high earner. He becomes a "company man" in the eyes of his fellow workers, in some concerns. Union pressures against high individual productivity may be a factor. A positive correlation between high morale and high productivity is more likely when the employee receives group approbation for superior performance. The intangible values resulting from success are quite as important as the tangible monetary rewards which may be provided by wage incentives.

Coöperation is a condition of working together. In its extreme negative form it may result wholly from compulsion based on fear. Under this condition, subordinate executive and operative employees do promptly in the prescribed way what they are told to do, but no more. As a result, the degree of organizational effectiveness, beyond that resulting from physical efficiency, is the degree that can be sustained by means of direc-

tion and supervision backed by authority. In its extreme positive form, coöperation results entirely from volition. Such coöperation cannot exist, for various reasons, except in the simplest organizational situations. A satisfactory degree of willing coöperation is possible. Willing coöperation may be any condition of coöperation in which individuals and groups in an organization work together voluntarily to achieve common objectives. Coöperation is the basis of self-coördination, as distinguished from executive coördination. It reduces the load on the executive, makes leadership more effective, and confers other benefits on the organization. Any coöperation requires some subordination of personal ideas and desires to those accepted by the group as a whole. In business, this means a voluntary and reasonable subordination of personal interests to the organization's service objectives in order that the latter may be achieved successfully. In consequence, coöperation is largely a result of good organizational morale.

Loyalty is that mental state which induces individuals and groups to give allegiance to a person or cause, to support it faithfully in the face of possible injury to personal interests. It is manifested only in situations that involve a possible sacrifice. Loyalty depends again on confidence in the leader's ability to guide the group to the successful achievement of its objectives. It depends also on confidence in his integrity and his willingness to share success with his followers in some reasonable degree. Loyalty is obviously an effect of morale. Loyalty in business has to do with giving allegiance to executive leadership in achieving the company's service objectives. It assures the executive that his leadership will be accepted willingly. His instructions will probably be carried out promptly and enthusiastically. Support will be more continuous during depressions or other periods of stress. However, loyalty is given voluntarily, and cannot be bought by elaborate service schemes or by pay increases. It is seldom given to executives whose ability is not respected; whose ethics are open to question. It cannot be gained by leaders who advance their personal interests at the expense of the legitimate personal interests of the led.

Good discipline is closely allied to loyalty; it may be defined as a mental condition which leads individuals and groups to accept executive direction and supervision willingly. It induces them to conform voluntarily to policies, rules, and regulations which are set up to promote an effective accomplishment of objectives. Good discipline is a result of morale development. The close relationship between them is evidenced by the breakdown of discipline that accompanies a strike.

Organizational stamina, another closely related effect of morale, is that

mental condition of organization which induces in individuals and groups a willingness and determination to carry on in the face of difficulties. A company may enjoy a satisfactory degree of loyalty and discipline under ordinary conditions. It may lack the will to continue operations when adverse conditions persist over an extended period of time. Organizational pride also is closely associated with these effects of good morale. It is the feeling or sentiment toward the company that may be held by executivees and operatives when the organization is accomplishing its service objectives successfully. Organizational pride is derived probably from satisfactions of the egoistic and creative urges. These satisfactions may be gained through participation in its accomplishments. Employees who have this feeling often strongly resent direct attacks on the company by outside sources. They are quick to rise to its defense. Interest in the organization and its work, application to the job, and intelligent exercise of initiative can also be shown to result largely from good morale.

Such values are vital to the success of the organization and its executive leadership. There may be a serious difference between present and maximum organizational effectiveness when morale is poor. For all these reasons, progressive concerns have been keenly interested in developing programs to create and maintain morale.

The Morale-Building Process

The basis of the morale-building process is the integration of interests. It is any process that develops and maintains identities and interdependencies between the organization's service objectives and the personal objectives of its members. It involves the provision or adjustment of the various morale factors in the situation, as they affect the relation of interests within the organization. It establishes these interdependencies principally by demonstrating the following proposition: A continuing and reasonable satisfaction of personal objectives depends fundamentally on a continuing and successful achievement of the company's service objectives. Therefore the integrating process may involve public relations, dealer relations, and customer relations, as well as investor, labor, and management relations. Its effectiveness depends on the development of a common understanding of mutual problems. It requires a sincere desire on the part of everyone to settle these problems equitably through an appeal to facts rather than to force. It must recognize that the interests of employer and employee are neither wholly coincident nor completely opposed. It must demonstrate by concrete results that a mutuality of interests can exist.

It attempts to work out fair and reasonable compromises, when interests tend to be antagonistic. Compromise becomes appeasement, however, when it involves a sacrifice of sound objectives and principles. Appeasement violates the primacy of the service objective, usually, by advancing personal interests within the organization at the expense of primary service objectives. Appeasement by industrial executives tends to result in the loss of leadership positions, resulting further in an unsatisfactory accomplishment of the organization's primary mission. It is, accordingly, a moral violation of executive responsibility. The executive can and should compromise reasonably, nevertheless. The principal phases of the morale-building process include, therefore:

1. Development and exercise of good leadership at every organizational level
2. Analysis of individual and group interests and their relation to organizational service objectives
3. Establishment of common concepts and yardsticks of sound values
4. Development of agreement by conference, participation, or other means, concerning what constitutes a reasonable satisfaction of employee interests
5. Provision, in adequate and proper amounts, of those values that are desired and may reasonably be expected by the employee
6. Prompt discovery and equitable adjustment of conflicts between personal and organizational interests
7. Continuous identification of personal interests with organizational objectives
8. Morale maintenance

The essence of subversive action is the prevention of the operation of the morale-building process by the organization's leadership. The general problem of executive leadership has been discussed earlier.

The Analysis and Evaluation of Employee Attitudes

Employee attitudes reflect the morale of the organization. Some knowledge of these attitudes is necessary in gauging morale, and in formulating a program to improve it. The opinions of operative executives on employee attitudes have been proved unreliable many times. Those of elected employee representatives are frequently no better. Some concerns undertake regularly the investigation and analysis of these attitudes for these reasons. Large companies spend annually many thousands of dollars to investigate customer needs and desires. It makes possible a more accurate determination of service objectives. Morale is a limiting factor in organizational effectiveness. The investigation of employee attitudes would seem to be quite as practical and necessary as customer research.

The various methods which have been developed for this purpose may

be classified as: (1) listening in, (2) interview, (3) questionnaire, and (4) supervisory evaluation of employee behavior.[4] When the listening in method is used, observers are put into operative jobs in the plant; their status is ostensibly that of an operative employee. The proponents of this method feel that a more accurate understanding of the employee's attitudes can be gained if, unknown to them, a trained observer listens in on their conversations with their fellow workers. An employee is more likely to react freely and naturally in his normal environment than under the somewhat artificial conditions presented by the interview or questionnaire methods. This method does produce valuable information, but its use is both dangerous and questionable. It has been alleged that this method has been used by union organizers to spot areas of discontent among a company's operatives. The use of undercover observers by management will promptly be labeled a spy system, nevertheless. Most personnel authorities do not favor the listening in method, for these reasons.

The interview method attempts to obtain information through private talks with the individual employees. The groundwork for these interviews is usually laid in advance by general education concerning their purposes and the uses to which the information will be put. Assurance is given that the employee's interests or standing will in no way be affected. The basic principles of interviewing apply, of course. There are various types of interviews that may be used. Some personnel authorities prefer the unguided interview for morale surveys. This type allows the conversation to proceed naturally, without guidance by the interviewer. Its proponents believe that under these conditions the employee is more likely to discuss freely and completely those interests and difficulties that most concern him. A variant of this method is the use of shop personnel counselors, by some companies. Employees are encouraged to talk over their problems with these counselors. They have no authority. Their interviews with the men are confidential and unplanned. The interviewers make no attempt to advise the men as to what they should think or do. The facts are reported to the management. These reports merely interpret trends of thought and significant group attitudes in the shop; individual cases are not discussed.

Any interview method has certain disadvantages. Interviews are slow, time-consuming, and expensive. It is often difficult to convince the employees that these talks will be entirely confidential. The interview method has flexibility, on the other hand. The interviewer has an opportunity to

[4] These methods may be classified as formal and informal. See R. C. Davis, *The Fundamentals of Top Management*, Harper & Brothers, 1951, p. 57.

bring out every aspect of the employee's interests and their relation to his attitudes. This method, in the hands of a skilled analyst, can produce excellent results.

The questionnaire method attempts to get an overall picture of the employees' interests and attitudes with a minimum of time and expense. The questions are those, of course, which the designers of the questionnaire consider pertinent to the particular morale problem. These attempt to bring out employe opinions that will indicate (1) the extent to which certain recognized morale effects are present, (2) the values that constitute the employees' interests, and their order of importance, (3) the employees' opinions of the order in which the management gives thought to and provides these values, and (4) the morale factors in the problem that are operating to create either high or low morale. The answers to the first type of questions give a measure of the level of morale. These show the extent to which a program is needed, and may suggest avenues of approach to its formulation. The degree of agreement between (2) and (3) measures management's success in developing a satisfactory integration of interests. The questions themselves, of course, indicate the employee interests that require attention. A ranking of the departmental scores on the morale questionnaire shows which departments should receive attention first. A correlation of the answers to the first type of questions with the fourth type shows which morale factors have the greatest influence. When, as is sometimes done, the questionnaire is given to the executive group also, the degree of agreement between the executive and employee answers measures the extent to which the management understands the morale problem. There are still other ways in which such questionnaires make available information that is basic to its solution. The use of questionnaires has the advantage that they may be given to large groups with a minimum of time and expense. The questionnaire method, on the other hand, may overlook important individual interests, and unless carefully designed, may not give proper consideration to group interests. The employees must be convinced that the questionnaires are not keyed in any way that will permit their personal identification. There is an additional disadvantage. Questionnaire surveys of employee attitudes usually are not taken more often than annually or semiannually. The morale of a manufacturing organization can change greatly within the time between surveys. An unexpected breakdown of labor relations can be costly.

Most foremanship programs give supervisory executives considerable training in the handling of operative morale problems. They go into the

techniques of order giving, grievance handling, disciplinary action, and related methods. The supervisory executive exercises a face-to-face leadership of his operatives. They have a tendency to come to him with their problems when he has their respect and confidence. The need for a shop personnel counselor is eliminated largely when the supervisory executive performs his leadership functions properly. He should be able to evaluate this information with respect to the morale of his organization. Some training must be given, however, before he can do so reliably. The gap between annual morale surveys can be bridged, when this has been done. The departmental executive should be required to make at least monthly a brief report of the morale of his group.

There are additional sources of information on employee attitudes, such as analyses of labor turnover, dismissal interviews, complaints, etc. Personnel executives seem to feel that these sources are too inaccurate to be sufficient in themselves. Therefore they should be supplemented by some other more direct method of investigation. Valuable collateral evidence can be provided nevertheless.

Sociometry and Morale

Many social psychologists have become interested in the social relations of groups within the business organization. A term that is still new to many industrial executives has been introduced, by them. It is the term "sociometry, the measurement of attitudes of social acceptance or rejection, through expressed preferences, among members of a social grouping."[5] It is evident that sociometric measurement and morale measurement are different techniques. The scope of the sociometric measurement is broader. It may be related to morale measurement, however, when applied to groups composing a business organization.

Sociometry makes possible a statistical measurement of the social satisfaction that is gained by individuals from group compatibility. This satisfaction is an intangible but very real value. It is one that most employees want and hope to gain from their work. The integration of this value with the service objectives of the organization is difficult because the bases of social compatibility may lie outside of the business organization. Social compatibility within working groups is, nevertheless, a morale factor in the business organization.

Sociometry aids in finding those groups whose members are compatible with one another. It may establish, inferentially, those individuals who are rejected by the group to which they belong. Such employees may be po-

[5] *The American College Dictionary*, Harper & Brothers, 1947, p. 1146.

tential sources of friction, discontent, and trouble. It indicates often the individuals who exercise an unofficial leadership of so-called "informal" groups within the formal organization. There is nothing wrong with such leadership. A good foreman usually knows such leaders in his department. It may be helpful to know them, since these individuals may be potential candidates for supervisory positions. They may also be communications transmission belts in the factory grapevine. The "grapevine" can be used to transmit facts that correct a rumor which is unsettling morale. It is possible to improve group compatibility once the informal groups have been located, and the conditions of compatibility have been determined. The transfer of "rejected" individuals is one method.

The development of informal groups is not necessarily helpful to organizational morale. There may be some serious opposition between the personal interests of different groups. Opposition of religious interests caused serious trouble between certain departments in one company. This is an unusual instance, of course, and should be. There are other difficulties that can develop, however.

Value Concepts and Morale

Good morale requires common concepts of proper organizational and personal objectives, and the nature of sound relationships between them. These are part of a sound management philosophy. An understanding and acceptance of them by both executive and operative employees is necessary for a satisfactory integration of interests. The organization's primary service objectives are values that the public has a right to expect. The *legitimacy of personal objectives* depends on the degree to which they have a reasonable relation to the organization's service objectives. These usually appear reasonable when the desired values are in proportion to the worth of the individual's job. Its basic worth is relative to the value of the service contributions of other jobs. The individual may receive incentive earnings and various fringe benefits in addition to his base pay. These values appear reasonable also when the cost of providing them is competitive. The customer, in a free-market economy, should be able to decide eventually what are reasonable costs and profits. This ability is usually modified, in a democracy, by political influences. There may be accordingly some temporary interdiction of labor monopoly, price maintenance, governmental intervention, planned inflation, and similar influences on the market process. The quality and quantity of the employee's service contributions depend, furthermore, on the contributions of management and capital, as well as on his own efforts. They depend, for

example, on machines, tooling, methods development, better materials, training, and other means of improving labor effectivity. It is evident that the value relationships involved are complicated. Development of common value concepts requires, accordingly, considerable education of everyone in the organization. This discussion briefly will continue, therefore, when we come to the work of employee education and training.

The Development of Agreement Between Management and Labor

The development of agreement concerning what constitutes a reasonable satisfaction of employee interests requires some process. It can be accomplished in some degree by individual bargaining. It can develop also as a result of effective action programs, based on attitude surveys. Such agreement may grow, without formal conferences, by intelligent applications of the principle of participation. This principle says that important experiences, understandings, and satisfactions may be gained through active participation in what is believed to be a worth-while activity. This tends to produce an integration of organizational and personal interests. The greater understanding which results from communication and education tends also to result in agreement. Collective bargaining is the principal process in most concerns today, however. This is true, at least, in so far as money and related tangible values are concerned.

Collective Bargaining

Collective bargaining is a process by which an agreement is reached between the representatives of the owners and the representatives of the employees of a business, concerning the compensation and conditions governing the purchase and sale of the employees' services. The term compensation is being used broadly here to include any tangible values that the employee receives in return for a satisfactory discharge of his contract of employment. It includes chiefly base hourly wages, incentive pay, and fringe benefits. The term conditions is frequently broadened by definition to include far more than working conditions and hours of work.

Management's attitude toward collective bargaining is complex. It recognizes, of course, the employee's property right in his services. This is the basis of individual freedom, which recognizes, accordingly, his right to sell his services personally or through agents on the most advantageous terms. It does not deny, therefore, the employee's right of collective bargaining. There must be an agency before one can sell one's services through an agent. Individual freedom therefore does not oppose union organization. Any denial of the right to organize and to bargain collec-

tively would constitute a denial of the right of private property, on which the free enterprise system rests. It does object to certain union policies and practices which interfere with a proper performance of management functions. It believes also that there must be a right to work that is coequal with the right not to work, since the employee has a property right in his services. The obstruction by force of the exercise of this right to work, through the instrumentality of the picket line, denies to the employee free access to his market, the employer. The term "force," as used here, refers to any pressure whether social, economic, political, or physical, to compel the acceptance of an assertion of claims to which a right is alleged. Employers' associations have been sponsoring right-to-work laws in state legislatures. Labor leaders have opposed vigorously the passage of such laws, since they weaken the potency of the strike as an offensive weapon. The U.S. Supreme Court ruled, in March 1953, that such laws are constitutional.

Management has many objections to certain union policies and practices. Some of the objections are sound, and some are not. We can only comment on a few which have some substantial support.

1. Interferences with the executive's right to manage
2. Deliberate weakening of the leadership position of executives at every level of the organization
3. Union attempts to break down organizational morale
4. Domination of the industry or the company by professional labor leaders
5. The use of force and violence in labor disputes
6. Union restriction of production
7. Passive resistance to managerial and technological progress
8. Monopoly labor prices and costs

The executive's right to manage is his right to plan, organize, and control the activities of the business organization, to the end that the organization may have an effective, economical accomplishment of its objectives. The primary objectives of the business organization are those values with which it must serve its customers. The organization must give them first consideration for some very practical reasons that have been discussed previously. This right to manage includes the right to make the decisions and to issue the necessary instructions and orders on which results depend. It rests with the executive, as the delegate of ownership, because of the right of private property. It rests also on the dependence of a high standard of living on the productivity of capital. There have been strikes to prevent a change in the location of a plant to one that is more economical. There have been instances of strong opposition to the installation of cost-

reducing methods and equipment. Union leaders have insisted, in some companies, that promotions of operative employees must be made on the basis of seniority. Yet executive accountability for results depends on the right to pick the people from whom the results must be obtained. The definition of the terms "compensation" and "working condition" have been broadened progressively in union contracts and court decisions. The result has been a substantial reduction in management's rights of decision. Management's prerogatives do not include any rights of decision concerning what should be the employees' personal objectives, of course. It should include the right to determine and control customer costs and services. Any substantial reduction in executive authority with respect to the latter may weaken seriously executive leadership in the accomplishment of primary and secondary objectives. This may be compounded further by the efforts of union leaders to transfer employee loyalties from company executives to themselves.[6] The strategy of some unions has been to insist that all benefits which the company provides for its employees must be bargained out with union representatives. Their demands can always exceed anything that management representatives can afford to grant. They are able to claim, as a result, the credit for obtaining any additional benefits and advantages that the employees receive from the company. This tends to defeat attempts by executives to develop an integration of interests within the business organization. It may break down morale, accordingly, and transfer loyalties to union leaders. Managements' reaction to this strategy has been to develop hard bargaining policies. It has adopted aggressive industrial relations programs in an effort to win back the leadership of its employees. Union leaders allege that this strategy is a union-busting technique that defeats collective bargaining and practically forces a strike.[7] Management leaders deny this. They allege that the term

[6] Dr. Leo Wolman has expressed this point of view as follows: "For what the new union is attempting is to transfer the loyalty of employees from the management to itself . . . the union is actively engaged in defining an inevitable and universal conflict of interest, since without this conflict there can be no lasting union organization." *The Nation's Business*, February 1953. (This author does not concur with Dr. Wolman's last conclusion.) See also "The Future of Labor-Management Relations" in the *Proceedings of the Congress of American Industry*, December 1954.

[7] The essence of this strategy appears to be the following: (a) Management makes an offer, after the start of contract negotiations, that it believes to be fair, and the best that it can do; (b) This offer is put into effect immediately for all nonunion employees, and those union employees whose leaders accept the offer; (c) The offer is publicized throughout the company and the community; (d) Management refuses to make the offer retroactive for union employees whose leaders do not accept it. Management takes a strike, if necessary, to enforce this decision; (e) Management refuses to make any substantial increase in its original best offer unless union leaders can show just cause; (f) It carries out scrupulously the provisions of the union contract, as finally negotiated; (g) It initiates activities, whenever possible during the

"bargaining" is a minomer in the case of many small concerns, because the term implies the absence of duress and the existence of an alternative choice. The use of force and violence by unions during strikes is well known. The intent is obviously to coerce the employer into accepting the demands of union leaders. It is used also to prevent the return to work of employees who do not wish to strike, or new employees who are satisfied with the terms and conditions of employment that the strikers have rejected. Union leaders maintain that violence in labor disputes is merely the spontaneous reaction of outraged employees who feel that their rights have been violated. The use of violence seem to follow a general pattern, however. This use has been recurrent over the years, furthermore. The arguments of union leaders are vitiated in consequence. There have been many articles in periodicals dealing with labor racketeering, the domination of an industry or business by labor leaders, union restriction of production, deliberate restriction of labor supply to maintain high wage rates or union control, resistance to managerial improvements or technological progress, and other union abuses.[8] Management leaders object also to wage demands based on ability to pay, on the grounds that they are assertions of nonexistent rights to profit shares. They object also to the political nature of union organizations, and the attempts of some of them to achieve economic objectives by political means. These are really objections to activities that tend to weaken the right of private property and promote socialism.

There is another side of the argument, as always. There have been many instances of alleged conspiracy between certain business and union leaders to limit competition in a certain locality in return for a union monopoly of the right to work. Many business executives have no objection to paying a monopoly price for labor, so long as they can add their percentage of profit on top and pass the entire package to the public. The lobbyists of businessmen, including farmers, have pressed for various forms of price-maintenance legislation. Many executives appear to be

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year, that benefit employees over and above contract requirements. These benefits are given directly to the employees; (h) It carries on a continuous program of education designed to sell executive leadership to the employees, and to develop an integration of organizational and personal interests; (i) It carries out other phases of the morale-building process that have been outlined in this book. See also the author's discussion of morale in his book on *The Fundamentals of Top Management*, Harper & Brothers, 1951. Union leaders refer to this strategy as "Boulwareism," because of the original use and advocacy of it by Mr. Lemuel R. Boulware, Vice-President, The General Electric Co. (An article on "Boulwareism" by Stephen K. Galpin, in the *Wall Street Journal*, Nov. 3, 1954 gives a good popular discussion of it.)

[8] Union organizations do not oppose improvement and progress officially. Mr. John L. Lewis has encouraged, rather than discouraged, mechanization in the coal industry.

interested chiefly in competition for their suppliers. The lack of regard for employee interests in the past, when labor organizations had not achieved their present size and strength, is still remembered by the public. Labor leaders can present an impressive list of countercharges. The preceding discussion can be summarized as follows: Collective bargaining is an integral part of the free enterprise system, since it rests on the right of private property. Labor organization is here to stay, in consequence. The manufacturing executive must maintain his position of leadership within his organization, in so far as the accomplishment of its primary and secondary objectives are concerned. He must bargain with employee representatives fairly but firmly, in matters affecting the employees' personal interests. He can not go beyond those that are directly concerned with the employment relationship, of course. He should coöperate with labor leaders, when he can, in developing a practicable labor-management philosophy that protects the public interest. The alternative, of course, may be increasing governmental control of both labor and business organizations.

The details of collective barginiug agreements are of great interest to personnel executives. They wish to know what are the trends in bargaining. They find sometimes that the statements by union representatives of concessions that have been granted by other local concerns are not correct. Chambers of commerce, industrial associations, and collegiate schools of business administration may collect and classify contract clauses for these reasons. The Indiana State Chamber of Commerce, for example, found the following clauses in more than 50 percent of a large sample of Indiana union contracts: layoff, recall, arbitration, automatic contract renewal, grievance committee, night-shift differential, union dues checkoff, employee probationary period, reëmployment of veterans, union shop. The following clauses were found in less than 50 percent of the contracts: health and sanitation, safety, mutual consent clauses, sick leave, health and welfare plans, escalator clauses for wages, pension plans, maintenance of union membership, severance pay, and closed shop provisions. The order of frequency of these clauses is the order of their statement.[9] The order of emphasis will be different in 1960. Some of the clauses may not be in the line-up at all.

Many concerns have found that the employees do not understand the various provisions of the collective bargaining contract. It is an inefficient

[9] Keith Davis, and Robert Parker, of the University of Indiana, *Collective Bargaining Contract Provisions in Indiana, 1949 to 1954*, Indiana State Chamber of Commerce, 1955.

instrument for coöperation unless they do. Some concerns have restated the contract clauses in nontechnical terms. They have supplemented the statements with accurate but simple interpretations. They have used various educational media and methods to develop employee understanding.

Collective Bargaining and Labor Organization

A trades or labor union is any association of employees that is formed for the purpose of gaining economic or social benefits for its members primarily through collective bargaining with employers. Membership is not confined necessarily to a particular company or industry. Its proponents point to the fact that it creates equality of bargaining power between capital and labor. The essence of bargaining power is the ability to wait. This is extremely difficult for the individual employee because he is necessitous as compared with his employer. The latter can and may take advantage of this to compel an employee to accept unfair conditions of employment. The greater economic strength of union organizations enables the employee to protect his own interests adequately, if, for example, his employer attempts to economize through unjustifiable wage reductions. Furthermore, national or state labor organizations can often get legislative action when it is necessary to protect the workers' interests. This is particularly important when these interests extend beyond the individual concern or the industry. It is also contended that strong national unions enable the employer to deal with a responsible organization, representing his employees. It can aid in stabilizing conditions in the industry. For example, the union can help to equalize labor costs among competitors. It can develop and maintain an adequate supply of labor of the requisite skill and knowledge, and can establish a mechanism for coöperation between management and operative employees in which the latter have confidence. Union leaders list other advantages. They claim that they are primarily responsible for most of the benefits granted by employers since World War II.

Critics of unions have pointed out that industrial peace depends on an unstable balance of industrial power. This is increasingly true with the development of company-wide and industry-wide bargaining between large business and labor organizations. A balance of social and economic power may assure a working compromise, but not necessarily justice. The power of the union rests on a monopoly of the right to work. Its unregulated development may eventually be detrimental to the public interest. This power is supported by the right to strike; this includes the right

to engage in industrial warfare to compel the acceptance of union demands. A great economic power that is largely uncontrolled usually results in abuses. During a strike, for example, the right to work, which is fundamental, is usually ignored.

Unions claim to be democratic organizations which represent the workers' interests. Many of them are. Some are anything but democratic. They are often controlled by machine politics and are dominated by professional labor leaders. It is alleged frequently by labor critics that membership is built up by coercion and intimidation, rather than by voluntary action on the part of employees. When management is compelled to accept the union shop and the checkoff, the labor leader can dominate the employees' actions. He acquires great economic power, in consequence. When this leader becomes so powerful that the workers can no longer hold him accountable for his use of this power, the result may be serious corruption within the union. Almost every great city has had its trial of labor racketeers, and has been appalled by the startling disclosures brought forth. The legislative contributions of unions to the development of fair labor standards is recognized. It is often pointed out, however, that they represent merely another group of special interest that tend to elevate these interests above the public interest just as does any other pressure group. Management objections to certain union policies and practices also have been noted previously.

Union labor organizations can be classified broadly, with respect to scope of activities, as general unions and independent unions. They may be classified, with respect to range of operative skills and interests, as industrial unions and craft unions. General unions are usually national in scope, with substantial memberships in the manufacturing and mining states. Their memberships may be organized on an industry basis, but their activities are not restricted to specific industries. They may be organized further on a craft or an industrial basis. The independent unions are not necessarily national in scope. They are usually associated with an industry, and sometimes with a company.

The industrial union is a labor organization that includes all operative employees in an entire industry regardless of the skills level at which they work. It is sometimes called a vertical union for this reason. Its protagonists contend that this form of organization enables labor to present a more united front in bargaining with employers. The industrial unions have generally been more militant than the trades unions. The outstanding example of this type of union was the Congress of Industrial Organizations, commonly known as the C.I.O. It was composed of locals for

each company or each independent operating division within an industry. These locals were members of and owed allegiance to the industrial union for the particular industry; for example, the locals of an automobile manufacturing company were members of the industrial union for the automobile industry, the C.I.O.-U.A.W. There were also the C.I.O.-Steel Workers. The C.I.O. was obviously a general union. The C.I.O. merged with the American Federation of Labor to form the A.F.L.-C.I.O. in 1955.

The craft or trade union is a labor organization that includes all operative employees in a given craft, regardless of the business or industry in which they work. For example, the molders in a given foundry may be members of the local molders' union; they may have their own shop steward or representative, who is elected by and from their own number. This local union will attempt to enroll every molder in every concern in the community. If the shop is completely unionized, the other craftsmen will belong to other unions. The local molders' union owes allegiance to a national molders' union. The latter was affiliated with the American Federation of Labor, the chief protagonist of craft unionism, prior to its merger with the C.I.O. Trade union organization was not quite this simple, however. In order to coördinate local activities, there was usually a city federation of labor to which the local unions belonged; the various city federations in a state were members of a state federation of labor, which in turn was affiliated with the A.F. of L. Moreover, under certain circumstances, the latter could charter locals directly. The advocates of craft unionism maintained, and still do, that the various crafts have problems that are peculiar to themselves. The community of interests is greater therefore among the members of a craft than among the various classes of operative employees in a company or an industry. They believed that the city, state, and national federations, with the coöperation of the officers of the national unions, could maintain the necessary coördination of the activities of the various labor groups. As a result of local autonomy, the policy established during the regime of Samuel Gompers, the control of union activities was decentralized in the A.F. of L. It was more highly centralized in the C.I.O.

The A.F. of L. and the C.I.O. merged during 1955, after some years of negotiation. They were still in the process of working out the merger details in 1956. The new A.F.L.-C.I.O. organization has approximately 16 million members at the present time, or 25 percent of our total work force. It has a great many millions of dollars at the command of its leaders. It will have great economic and political power accordingly.

An independent union is any labor organization whose membership is

confined to the operative employees of a particular company or industry. Its activities may be nation-wide in scope, however. The term "independent" implies that it has the financial strength and the freedom of action that is necessary for the effective advancement of employee interests. Of course no union, either general or independent, ever has complete freedom of action. The objectives of the independent union are fundamentally the same as those of the general union. They may be any social or economic benefits, secured through negotiation with management, that the employees seek. The structure and procedures of the independent union are similar to those of the general union. There may be, however, some fundamental differences in its industrial relations philosophy that entitle the independent union to be regarded as a distinct form. It recognizes to a greater degree, usually, that all benefits distributed in the business organization must come eventually from the consumer's dollar. It assumes that greater employee benefits can be achieved through coöperation with management than from attempts to coerce it. It may reflect the desires of the particular employees to advance their interests without recourse to industrial warfare, if possible. It takes many years before an employee can recover the losses in wages incurred during a major strike, even if his union wins. It may reflect also the desires of the employees to avoid involvement in national union politics.

The protagonists of the independent union claim that the individual employee is less subject to domination by professional labor leaders; that he is less likely to suffer from abuses of union power. This may be true in general. It is not true, certainly, of some whose leaders have been accused of communist affiliations. A greater ethical responsibility for fair dealing is placed on the business executive obviously, when he deals with the representatives of an independent union. There is the danger that some executives will not discharge this responsibility properly. There is always the possibility, of course, that the leaders of a large, successful independent may take their union into a larger general union. These leaders may be tempted by the greater prestige, power, and financial opportunities that may be gained.

There are a number of large, successful independent unions in the United States. The memberships of the independents, both large and small, is said to include approximately 2 million employees at this time. This suggests that the independent union probably has a permanent place in our national structure of labor organization. Industrial executives must deal today with the representatives of powerful, well-staffed, and well-

organized labor unions. It is necessary, accordingly, for the executive to understand union organization and strategy.

The Labor-Management Relations Act

The National Labor Relations Act, known as the Wagner Act, was passed by Congress in July, 1935. It was upheld by the U.S. Supreme Court in April, 1937. The intent of the Act was to guarantee and make effective the employee's right of collective bargaining. It was administered by a National Labor Relations Board of three members, appointed by the President. Strong objections to the act developed. It failed to diminish "strikes and other forms of industrial strife or unrest, which have the intent or the necessary effect of burdening or obstructing commerce." There were charges that the N.L.R.B. administered the Act unfairly, favoring the claims of union leaders. Many people considered that the Board's methods of investigating and handling complaints did not conform to the requirements of equitable legal procedure. It was objected that the Act created certain rights for organized labor, but no corresponding obligations. These rights extended greatly the powers and abilities of unions to organize employees and compel employers to bargain with union representatives. There were no limitations on the exercise of these rights that were sufficient to protect the public interest. Employers were prevented substantially from presenting their point of view to their employees. Union leaders were able, in effect, to engage in "thought control" in some degree, in so far as the operative employees of a unionized company were concerned. Employers complained bitterly of the infringement of their rights of free speech. Other objections were raised, not only by employers but by many public figures who were concerned principally with the public interest.

This act was amended, in June, 1947, by the Labor-Management Relations Act, known as the Taft-Hartley Act. This Act carried over from the Wagner Act the basic protections of employee interests. It reaffirmed the right of employees to form unions and bargain collectively. It confirmed all rulings of the National Labor Relations Board, except as specifically repealed. The principal provisions of the Taft-Hartley Act can be summarized as follows: The Act

1. States and prohibits the five unfair labor practices by employers, or their agents, that were set forth in the Wagner Act.
2. States and prohibits certain unfair labor practices by labor unions or their agents.

3. States certain employer rights and freedoms, as they concern his relations with employees and labor leaders.
4. States certain employee rights and freedoms, as they concern his relations with employers and labor leaders.
5. Provides certain protections for the public interest during labor disputes.
6. Makes certain changes in the membership, organization, and procedure of the NLRB.
7. Carries certain other provisions not included in the above.

It is not possible to discuss the Taft-Hartley Act and its provisions in any detail.[10] A complicated body of administrative and judicial rulings has been built up over the years. There are lawyers and labor-relations consultants who specialize in the field. We can indicate here only the general nature of the above categories. The five unfair labor practices by employers, or their agents, are: (1) interference with, restraint, or coercion of employees in the exercise of their rights of collective bargaining; (2) domination or interference with the formation or administration of a labor organization, or contribution of financial or other support to it; (3) encouragement or discouragement of membership in any labor organization by discrimination with regard to hire or tenure of employment, or by any term or condition of employment; (4) discharge or other discrimination against any employee because he has filed charges or given testimony under the Act; (5) refusal to bargain collectively with representatives of his employees. The principal unfair labor practices by labor organizations or their agents are: (1) restraint or coercion of employees in the exercise of their rights of self-organization or collective bargaining; (2) discrimination against an employee in violation of the employer's unfair labor practices. A labor union cannot conspire with the employer to avoid these prohibitions, obviously, or engage in like practices; (3) refusal to bargain collectively with an employer, provided that the union is the certified representative of his employees; (4) engaging in or inducing employees of any employer to engage in an illegal strike or boycott; (5) requiring excessive initiation fees for membership in the union. The right of nonmembers to bargain collectively cannot be limited for the purposes of labor monopoly, in other words; (6) "featherbedding" practices that cause or attempt to cause an employer to pay for services not performed or contemplated; (7) certain others.

The Taft-Hartley Act attempts to protect certain employer rights and freedoms. It grants, for example, freedom of speech in labor relations mat-

[10] An excellent analysis of the Act and its provisions will be found in M. J. Jucius, *Personnel Management*, 3d ed., Richard Irwin, Inc., 1955, pp. 427-435. An outline of the Act will be found in Thomas J. Luck, *What You Should Know about the Taft-Hartley Law*, Bureau of Business Research, Indiana University, 1948.

ters. The employer can express his point of view to his employees, including his opinion of the union, provided that there are no threats or inducements designed to restrain the employee from joining or not joining the particular union. He may discharge employees who engage in illegal strikes. He may sue a union for breach of contract. He is granted certain other privileges that he did not have under the Wagner Act. The present act attempts, conversely, to protect certain employee rights and freedoms. The employee, for example, cannot be discharged by an employer, at the insistence of a union leader, except for nonpayment of union dues. He cannot be compelled to join a union, except when a valid collective bargaining agreement calls for a union shop. The union shop is a shop in which the management may hire a nonunion employee, but the employee must join the union within a stipulated period of time. The union must have been accredited by the NLRB as the collective-bargaining representative of the employees. A majority of all employees in the particular bargaining unit must have voted for a union shop in an election conducted by the board. An employee can now take a grievence directly to management, without going through a union shop steward or business agent. The employee is given certain other protections of his rights as an individual citizen. The Taft-Hartley Act attempts also to offer some protection to the public interest in labor disputes. It contains certain provisions designed to insure the continuance by business concerns of the economic services to which customers are entitled. They represent some recognition that the primary objectives of the business organization are customer values, and that the personal benefits desired by owners and operatives are collateral objectives. The NLRB, for example, can petition the courts for an injunction restraining a union from engaging in a secondary boycott or illegal strike. The President has the power to decide whether an industry-wide strike has created a national emergency that imperils public health or safety. The strike can be enjoined for a national period of 80 days, if he so decides.

The Act made certain changes in the organization and procedure of the National Labor Relations Board. Its membership was increased from 3 to 5, for example. It was required to follow the rules of evidence that are used by U.S. district courts. Other changes were made. The Act defines such terms as "collective bargaining," "strike," "a legal strike," and others.

Both management and labor leaders have raised complaints about the Act, as would be expected. Management leaders have complained that Labor Board attorneys still appear to represent union interests, rather than the public interests. They note that the sanctity of contracts is

violated when the union can call a strike to accomplish economic objectives at any time during the life of the contract, provided that it does not contain a no-strike agreement. They have other objections. Managemnt, in general, does not appear to have serious objections to the Act, however. Union leaders, on the other hand, have been violently opposed to it. They have referred to it as a "slave labor" act. Unions have attempted to secure its repeal, and the reënactment of the Wagner Act. Management has been defined as the function of executive leadership. The Act makes it somewhat easier for the executive to lead his employees in the accomplishment of his organization's service objectives. It may make it a little more difficult for labor leaders to organize nonunion employees. The facts are that the memberships, wealth, and power of labor unions have continued to grow under the Taft-Hartley Act. The rank and file of union members do not appear to want unrestricted economic and political power in the hands of professional labor leaders.[11] The general public appears to have little desire for any fundamental revisions of the Act. It appears unlikely, therefore, that any will be made in the near future.

PROBLEMS

1. A firm manufacturing fountain pens employed a work force consisting of approximately 70% female and 30% male employees. The company had for some time followed a policy of equal pay for equal work (although in general women were employed at semiskilled jobs which were paid a lower rate than skilled jobs). Smoking had recently been permitted at the workplace and employees were generally permitted to maintain an informal and congenial social atmosphere. Turnover was low and employees' attitude toward their jobs was considered to be favorable. An attitude survey had been made, a short time previously, by a firm of personnel consultants. An analysis of survey results indicated that employee job satisfaction was very good. The level of output was not satisfactory, however. When it actually dropped in several departments, management questioned the value of progressive and liberal personnel policies designed to improve employees' job satisfaction.
   (a) What might have been the possible causes of such a situation?
   (b) Is this an exception to the general principle that morale is an important factor in organizational and operational effectiveness?
   (c) What general approaches to an investigation and solution of this problem would you suggest?

[11] The results of a nation-wide Gallup Poll, on a proposal for government-sponsored secret strike ballots, were published in various newspapers during the summer of 1954. They showed that the public favored the secret ballot by a 3-to-1 majority, approximately; that union members favored the proposal by approximately the same 3-to-1 ratio. There have been more recent instances in which labor politicians undertook to deliver the organized labor vote to a favored political candidate but could not, judging by results.

2. A consultant in the field of methods improvement and motion study was engaged to lead a series of supervisory conferences on job methods training in each of a company's plants. The original objective was reduction of operating costs by increasing the supervisors' understanding of methods analysis and motion study by encouraging their participation in methods improvement, and by increasing their effectiveness in training operative employees. Several conference courses were held for operative employees as well. In almost every case where conferences were held, the morale of the operative organization was increased markedly. Other procedures were employed that apparently affected morale in a positive way also. It was quite evident to management, nevertheless, that the conferences contributed greatly to the development of morale.
   (a) Does this conclusion seem to be logical or illogical? Why?
   (b) Can the immediate objective of such a program be improved morale, or is the latter condition a result of an effective performance of other functions?
3. A clause in the agreement between the company and the union stated that production standards, once set for a job, were to remain unchanged, unless there were a significant change in materials, methods employed, or equipment. In the past when a standard had been set too low, the methods department had been known on occasion to make a minor change in methods to justify a restudy of the operation and the setting of a new standard.
   (a) What principles of personnel management were violated?
   (b) What effect would such an expedient have on morale? What probable results might one expect?
4. A manufacturing firm found itself, several years ago, in an unfavorable competitive position. It had granted wage increases during and after World War II somewhat more generously than had its competitors. Its product designs were not good enough to increase or even maintain its relative market position. Management informed the union leadership that a cut in pay rates would be necessary. Management convinced the union president of the validity of the argument. The president then agreed to request the union membership to accept a wage reduction, but with the understanding that restoration of lost wages would be made in the form of bonuses beginning the following year.

   Another firm producing automobile parts, including axles, gears, and similar items, found that it had priced its product out of the market in a way quite similar to that of the preceding firm. After considerable investigation, a program for an analysis of nearly all production operations in the plant was proposed by management and agreed to by the union. Wage rates were set by time study after the jobs had been reëngineered. Six union members, selected by the members themselves, were sent to a time study training course at management expense. It was their responsibility, upon completion of such training, to check any job standards with the company's time-study engineer, when such standards were challenged by employees. As a result, the complaints on standards were minimized, and the job redesign program aided greatly in regaining the company's competitive position. The firm in

the first instance adopted eventually a policy that limited its business to a narrow line of products that were not in direct competition with those that were mass-produced by other companies. It reorganized its operations on the basis of a sales volume that would be permanently lower than that which it had enjoyed formerly. It was able to restore its profit margins to a satisfactory rate, on this basis, after a few years.

(a) Both companies suffered a serious deterioration of their competitive position. What are the basic significances of such a development, and what major difficulties may result?

(b) Are the cases of the two companies identical, in so far as this loss of competitive position is concerned? Can you suggest any probable reasons why the first company was forced out of its original business? (It is recognized that it would be necessary to check any hypothesis against additional facts, but it is necessary to have something to check.)

(c) Would the solution that was applied in the case of the automotive parts manufacturer have produced the same results in the case of the first manufacturer? Why?

(d) Discuss these two case situations from the standpoint of their morale implications, and the principles of good organizational morale development that have either been applied effectively or violated.

CHAPTER 26 •

• Labor Relations and Employee Services

The Provision of Employee Values

IT was pointed out, in the discussion of the morale-building process, that management must provide those values that are desired and may reasonably be expected by the employees. These values have been classified previously as (1) tangible and (2) intangible benefits. The latter are those psychic satisfactions that one gets from association with a successful organization that is accomplishing its primary mission under good leadership. Such values are not usually sufficient when these conditions are not present. These values have been discussed previously. The tangible benefits are material values of one kind or another. The principal categories are (1) base wages, (2) incentive wages, and (3) so-called "fringe benefits."

BASE WAGES

A wage, in a broad sense, is any tangible compensation that is received by an employee for his services. It is necessary for payroll and other purposes, to distinguish between wage rates and salary rates. A wage rate is a rate of compensation that is paid for each unit of time actually served. An employee in a certain labor classification may get, for example, $2.00 per hour for each hour that he is on the job during his normal work week. A salary rate is a rate of compensation for a period of time. It is paid without regard for the amount of time actually served during the period. It may be a rate per week, per month, or per year. Executives and professional operatives are usually paid on a salary basis. This may be done with other types of employees who are also exempt from the time-and-one-half provisions of the Fair Labor Standards Act. It is possible, of course, to put nonexempt employees on a salary, but they must be paid

time-and-one-half for overtime. The reason for the salary is usually that the work of the particular employee cannot be confined to the normal working hours for his pay period. There are times, for example, when it is necessary for an executive to work nights, weekends, or holidays on the solution of an important problem. There may be little relation between the individual's contributions to the success of the concern and the number of hours that he actually works, when his work involves creative thinking.

Executives usually distinguish between base earnings and incentive earnings. The rates discussed in the preceding paragraph are frequently called base rates. The base hourly rate of an operative tends to approximate the going rate of pay in the community or the industry for people who are basically qualified for the particular class of work. It is the rate of pay usually for people who have been properly selected for the work, but have not yet had specific training for or experience with the particular job. We shall assume that the base hourly rate of a certain employee is $2.00 per hour and that he has worked a standard 40-hour week. We shall let E represent earnings, H represent hours worked, and R represent the base hourly rate. Then the straight-time earnings of the employee would be:

$$E = H \times R, \text{ or } 40 \text{ hr} \times \$2.00/\text{hr}$$
$$= \$80.00 \text{ for the week}$$

Every employee has naturally a very fundamental interest in monetary earnings. If they are insufficient, financial worries will cause dissatisfaction. This may be reflected in low morale, high labor turnover, and decreased production. If wage rates are not fair as between employees doing similar kinds of work, again dissatisfaction may result. The employees' attitude toward their wages has a direct and far-reaching effect on labor relations. Some concerns have established a definite policy of paying a little more than the community prevailing rates. It enables them to attract and hold a better class of workmen, and to develop better coöperation and morale.

Some economists believe that the base wage rate is determined fundamentally by the principle of the marginal efficiency of labor; in other words, the productivity of the last worker who can be employed profitably determines the compensation for that particular kind of labor. This principle may determine base wages over a long period of time. They may be affected by many other economic forces at any given time, however.

In discussing wage and salary control, many concerns use some method of job evaluation to determine base wage rates for different occupations or job classes. Modern industry attempts to evaluate these differentials accurately in setting up a wage structure. The employer has the right to determine what he thinks a job is worth. He should not be compelled to pay more than he thinks it is worth. The base rate, on the other hand, is the basis of the purchase and sale of the employees services. He has the right to determine what he thinks his time is worth for the particular class of work. He should not be compelled to accept less. The base rate structure is determined in most large concerns by collective bargaining between management and union representatives. Job evaluation information is used by management in many concerns as a basis for intelligent wage bargaining. The job and rate relationships developed by job evaluation have been accepted jointly in some cases. Such joint agreement reduces one possible point of dispute. Job evaluation will be discussed later, in connection with personnel research.

The Fair Labor Standards Act

The Fair Labor Standards Act, known also as the Wages and Hours Act, was passed originally in 1938. It set up legal wage and hour standards that affect wage payments greatly. The original act provided that wages should not be less than 25 cents per hour from October 24, 1938 to October 24, 1939; 30 cents per hour from October 24, 1939 to October 24, 1945; therafter 40 cents an hour, unless a preponderance of evidence could be produced to show that this rate would substantially curtail employment in a particular industry. The Act was amended in 1949, increasing the minimum wage to 75 cents per hour. It was amended again in 1955 to set a minimum wage rate of $1.00 per hour, beginning March 1, 1956. It was thought that approximately 2,100,000 employees would be affected at that time; that their wages would be increased by more than a half-billion dollars annually. The Act requires overtime pay of time-and-one-half the employee's regular rate for all hours over 40 in a work week. A minimum age of 16 years for general employment and 18 years for hazardous work is established. The Act applies equally to men and women in business establishments, regardless of the number of employees, except as exempted. It applies whether the employee is paid by the hour, salary, or piecework. The law does not provide extra pay for Saturday, Sunday, or holiday work, as such. It does not provide vacation, holiday, or severance pay. Such provisions may be included in collective-

bargaining agreements, of course. It does not limit the number of hours of work for persons who are 16 years or over. Certain types of employees are exempt from the minimum wage and overtime provisions, such as executives, administrative employees, professional employees, local retailing employees, and outside salesmen. The first three categories must meet certain tests to establish their status. They must devote 80 percent of their time directly to their occupation and receive a specified minimum salary. If the individual devotes more than 20 percent of his time to nonrelated work, this minimum is $100.00 per week. His work must require the exercise of discretion and independent judgment. An executive, in addition, must direct and supervise the activities of two or more employees. He must have the right to hire, fire, promote, or recommend such actions. Certain industries are exempt from either the minimum wage or overtime provisions, or both, as specified in the Act. Some of them are retail and service establishments, agriculture, seafood and fishing, newspaper publishing, and common carriers.

The affect of the Act on wages can be illustrated by the following examples. We shall use the symbols E = total earnings, H = standard work hours, H_0 = overtime hours, and R = base hourly rate or its equivalent, to simplify the discussion:

STRAIGHT-TIME PAY

$$E = (H.R.) + (1.5 \times H_0 \times R)$$

We shall assume that the particular employee has a base hourly rate of $2.00 per hour, as in the previous example; that he has worked 45 hours during the week, giving him 5 hours of overtime. Then:

$$\begin{aligned} E &= (40\,\text{hr} \times \$2) + (1.5 \times 5\,\text{hr} \times \$2) \\ &= \$95.00 \text{ for the week} \end{aligned}$$

STRAIGHT TIME PLUS INCENTIVE PAY

It is assumed that the basic conditions are the same as in the preceding example, except that the employee is working under some wage incentive system. It could be piecework, or some other. A distinction should be made between a base rate and an incentive rate. The latter is the percentage rate above base earnings that should be earned, under standard conditions, by the average employee who has been properly selected and trained for his work. He earns this percentage when he achieves the standard production rate regularly for his assigned operations. We have

defined previously the meaning of the term "fair production standard." We shall assume that management policy calls for an incentive rate of 20 percent above base. In such case,

Hours worked during the week	45 hr
@ Base rate of \$2.00 per hour	× \$2
Total base earnings	\$ 90.00 per week
Plus incentive earnings of	18.00 during week
Total base and incentive earnings	\$108.00 for the week
Regular (ave. hourly) rate	(108/45) or \$2.40/hr

$$E = (40 \text{ hr} \times \$2.40) + (1.5 \times 5 \text{ hr} \times \$2.40/\text{hr})$$
$$= \$114.00 \text{ for the week, including overtime}$$

Some employees will soldier on the job deliberately to get the work into an overtime period. The overtime premiums are one reason. Management, on the other hand, tries to control overtime work, and to avoid it if possible. Some companies have abandoned their wage incentive plans, because the incentive rate tends to pyramid overtime premiums. This is hardly a wise policy, despite the ability of automatic machinery or conveyors to control the rate of production. The reasons were discussed in connection with motion and time study.

Some executives, and some economists, have raised objections to the determination of minimum wages by law. They point out that the minimum base hourly rate has been increased periodically as a result of political action. The stated intent, of course, is to protect the purchasing power of employees whose earnings have become substandard as a result of inflation. The employees who are benefited are usually among the "100 percent spenders," rather than the savers. The increase in base rate is followed necessarily by the restoration of the normal rate differentials between labor classes. Otherwise, there may be little to induce able operatives to develop themselves and work for more responsible, skilled jobs. The incentive value of a company's base-rate structure would be reduced, in other words. A substantial increase in base rates by law contributes further to inflation, to the extent that there is no corresponding increase in the rate of production. It has been alleged that a legal minimum creates cost rigidities; that these will aggravate unemployment in the event of a major depression. There is no question, on the other hand, that there are some employers who would pay sweat shop wages if they could get away with it. It is unlikely that they could where there are strong unions. Neither union leaders nor the general public have

shown any great desire for any fundamental changes in the law. It is therefore most unlikely that any will be made in the near future.

There are other laws, such as the Walsh-Healey Act and the Bacon-Davis Act, that govern wage payments and overtime. The general executive should have a general knowledge of them. The personnel executive should have more, obviously.

Wage Incentive Plans

Some concerns pay employees strictly on an hourly basis. It is usually found, even in such cases, that many are paid more than the base hourly rate for their particular class of work. The difference in pay may be in part a recognition of length of service. It is frequently a recognition of superior performance in either quantity or quality, however. An incentive wage is usually a money payment, over and above the base wage, whose amount varies with the quantity or quality of output above a certain performance standard. Part of an operative's hourly wage in excess of the hourly rate may therefore be regarded as an incentive wage. Most concerns that wish to improve performance through wage incentives adopt a definite plan for this purpose, however.

An incentive may be any stimulus to action. The stimulus in incentive plans lies in the opportunity to acquire certain desired values. Incentive values are earned in addition to those that normally may be expected for normal performance. An incentive plan is a definite arrangement which provides an opportunity to obtain these values through superior performance, as measured by results. The desired values are necessarily some of the personal objectives of the individuals or groups concerned. They may be either financial or nonfinancial. The desired results are certain organizational service objectives. Money is a common denominator of value. It is something of which most of us never have quite enough; our desires are usually extensible far beyond the limits of our capabilities. An incentive plan enables the employee to earn more money, above his base wages, as he improves his performance above standard. An incentive plan may be a practical mechanism for integrating certain interests of the organization with certain interests of particular individuals or groups therein. It may accordingly build up morale. The converse is equally true. It is for this reason that the problem of incentive payments is of particular interest to the labor relations executive.[1]

[1] The importance of production standards as factors in the maintenance of satisfactory labor relations, is indicated by the figures on p. 745:

Some labor leaders have opposed the use of wage incentive plans by management. They have claimed that these incentives are "speed up" plans. A sound incentive plan, properly applied, has nothing to do with the so-called speed up. The latter is an attempt to exploit the employees' interests, rather than to integrate them. By exploitation is meant any effort to induce an employee to produce more than can reasonably be expected, and to accept in return a smaller compensation than he should reasonably expect. Some minor labor leaders, such as local business agents and shop stewards, seem to fear that the employee will work himself out of a job. They have some sort of a work-fund concept, apparently. They may regard incentive plans as unfair to employees whose productive abilities are substandard. It is not clear why it is fair to hold superior employees down to some dead level of mediocrity. It is clear that it may be good politics, since there are more people who lack superior ability than there are who have it. Some major labor leaders are regarded by some executives as socialists in some degree. Incentive plans violate the socialist principle: "From each in accordance with his ability, to each in accordance with his need." Such leaders could be expected to oppose the use of wage incentives. There may be other reasons for union opposition. In general, however, opposition to methods for increasing *per capita* production is not in the public interest. Objections to unfair performance standards or unfair methods of applying incentive principles are something else.

A distinction should be made between incentive plans for executives and for operatives. The plans for executives breakdown into two categories, those for administrative executives and those for operative executives. Plans for administrative executives have received much thought in recent years, for a number of reasons. These have to do with the con-

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Man-Days Lost Annually Due to Labor Disputes over:

Year	Overtime, Fringe Benefits, and Incentive Pay (1)	Production Standards and Incentives (2)	Percentage (2)/(1)
1949	3,150,000	694,000	22.0
1950	1,300,000	414,000	31.8
1951	2,240,000	568,000	25.4
1952	1,750,000	616,000	35.2
1953	3,280,000	549,000	16.7
1954	1,110,000	431,000	38.8
1955	3,720,000	943,000	25.3
Ave.	2,364,286	602,143	25.5

The data on man-days lost are taken from a table that was specially prepared by the Bureau of Labor Statistics, U.S. Department of Labor.

fiscatory tax rates in the high-income brackets, the tendency of successful executives to take an early retirement as a result, the increasing lack of mobility of important executives, and others. Such plans have included provisions for deferred salary, capital gains opportunities, pension privileges, and others. It is agreed that no organization is likely to be much better than its leadership. Our discussion, nevertheless, must be confined to wage incentive plans. Operative wages are more important from a cost standpoint than executive salaries. The former may constitute 85 percent or more of the total operative and executive payroll. Top executive salaries may not include more than 3 percent, despite their large individual size in a few instances.

Wage Incentive Principles and Policies

The introduction of an incentive plan involves a number of considerations. These should be taken into account if it is to get the desired results, and at the same time maintain or improve morale. Some of the more important will be noted briefly.

An objective has an incentive value in itself. The plan should provide for objective standards of work, fairly and accurately determined. They should be definitely stated in measurable units of constant value, so that accomplishment may be evaluated fairly and accurately. For example, a performance standard can be expressed in dollars to be paid per unit of physical output. It can be expressed also in units of output per unit of time. The latter is more satisfactory because the value of money varies with the business cycle. When the standards are fair, an employee may gain certain psychic satisfactions associated with successful accomplishment. This is more likely to be the case when the employee group feels that high individual productivity is meritorious, and performance standards are accepted generally as fair and accurate. It is helpful under these conditions to inform individuals and groups of their relative accomplishments and to post these results periodically in their department.

Incentive plans may improve primarily the quality, quantity, or cost of results. These may apply particularly to individual or group effort. They may be suitable for executive or operative work and may be financial or nonfinancial. It is evident that an incentive plan might be admirably suited for one purpose and most unsuitable for another. Its incentive value—ability to hold results to standard or better—should be adjusted to the requirements of the problem. For example, a plan with high production standards and a high incentive value might produce too great a percentage of scrap or seconds. It would not be suitable, if the problem

were to increase the rate of production without decreasing quality. A plan with a high incentive value is usually more difficult to introduce; it may require the careful selection and training of employees for the job, a highly accurate determination of performance standards, and the close continuous inspection and maintenance of working conditions. Any plan should be understood, accepted, and supported by the people who must execute it. Otherwise it will not produce the maximum results of which it is capable. An incentive plan should accordingly be as simple and understandable as possible. One that might be suitable for an executive group might be too complicated for an operative group. The plan should enable an operative employee to compute his earnings easily and accurately. He may not give the company the benefit of the doubt as to honesty of purpose, when the payroll department computes his earnings at a lower figure than he does. Inasmuch as morale is an important objective, the employee should be made to understand the need for increased service values, and their relation to the increased values that he receives. For this reason it is often desirable to precede the installation of an incentive plan by an educational program.

Incentive earnings should be additional amounts received for increased output based on standard performance or better. Incentive earnings therefore should be paid in addition to base earnings. The incentive rate should be sufficient to stimulate performance of the desired kind and amount. It should be at least 10 percent of the base pay for standard performance. It usually runs between 15 and 30 percent for the average employee. A distinction should be made on the pay envelope or check, between base and incentive earnings. Otherwise, the total amount will eventually be regarded as the normal earnings on the job. This may diminish the incentive value of the plan and create other difficulties. The operating cost of the plan should of course not exceed the savings it makes possible. The time between achievement and the payment of the reward should be as short as possible. Otherwise an employee will lose many satisfactions inherent in superior accomplishment. The relation between above-standard performance and extra earnings is less evident. An excessive time lag of incentive payments reduces the incentive value of the plan accordingly. There are many successful nonfinancial incentive plans in industry. The tendency is to include as many financial and nonfinancial values in a plan as is practicable.

Of course, many morale principles apply to the offering of incentives. For example, the success of an incentive plan depends in part on the employees' confidence in the fairness of their executives. Inasmuch as the

plan usually affects the interests of a large number of employees, group conference leading to acceptance by the group is often desirable.

The many wage incentive plans which have been developed may be classified as individual or group plans. In most cases these are intended to increase the quantity of work rather than its quality. The quality is usually maintained through close inspection. To illustrate the application of incentive principles a few plans will be discussed. There are many other plans with which the student of labor relations should be familiar.[2]

Day Work with Production Standards

Some concerns prefer not to offer a direct financial incentive for increased production. They may wish to avoid the risk of lowering quality. Some unions have objected to the use of financial incentives. In such instances, a plan that relates the payment of base hourly wages to production standards may be adopted.

Under this plan, production standards are usually set by time and motion study. At the end of a given period, usually one month, the total of the standard times for all completed jobs is divided by his total clock time for the period. The resulting figure gives his overall productive efficiency for the period. The clerical expense involved in determining output is likely to be a minimum with this system.

The employees are often ranked on the basis of their efficiency, and their comparative standing posted on their departmental bulletin board. Each workman's productive rating should be entered on his personal service record, under conditions of intermittent manufacturing. This information, together with his length of service, health record, number of dependents, etc., should be considered in connection with promotions. His productivity may be linked to his hourly earnings by means of a sliding scale above his base rate. His base hourly rate is guaranteed, of course. The employee's productive efficiency is computed at the end of the month. The base rate may be adjusted accordingly for the following month. The employee whose base rate is $2.00 per hour, for example, might produce at an average rate of 120 percent of standard, during the month. He might be paid at the rate of $2.40 per hour during the following month. The increases in base rate usually go up in steps, with corresponding increases in productive efficiency. There are variants of this plan, of course. Its incentive value, in any form is not so high as

[2] For an authoritative discussion of all types of incentive plans see C. W. Lytle, *Wage Incentive Methods*, The Ronald Press Company, 1942.

those that offer a more immediate and direct reward for the completion of a specific job within standard performance time.

The Piecework System

One of the oldest methods of paying wages in proportion to production is the straight piecework system, in which the employee is paid for his work at a given rate per piece. Originally with this system, production standards were estimated from past production records, or by the foreman or someone else who was considered competent. As a rule, the employee was paid only for the actual amount of work that he produced. If production was held up through the fault of the management, it was his misfortune. The straight piecework system often led to price cutting because of the inaccurate standards, and to serious trouble with operative employees.

The modern piecework system is based on production standards accurately determined by time and motion study. The employee's base hourly rate is guaranteed against loss from interruptions to production. In most cases, the production standards are guaranteed against change, except when there has been a substantial change in product or process, or the time-study department has made a substantial error. Assuming that the production standard for a particular operation is 50 pieces per hour, including all allowances, and that the base rate of our average employee on this operation is $2.00 per hour, the piece price then is 4¢ per piece. The employee should produce easily at the rate of 60 pieces per hour, when he has acquired the normal skill and experience. He will earn then at the rate of $2.40 per hour. The piecework system in one form or another has been widely used because it provides a simple, inexpensive, but effective incentive plan.

The Taylor Differential Piece-Rate System

While at the Midvale Steel Company, Frederick W. Taylor developed a method known as the differential piece-rate system. Production standards were determined by time and motion study. Two piece rates were set for each job on the basis of the standard. The high rate was paid those who produce at a rate equal to or greater than the standard. The high rate was so set that the average employee earned approximately 125 percent of base production standard. The employee who failed to produce at the standard rate was paid the low piece rate. This was so set that he earned approximately 80 percent of base.[3] He was therefore penalized

[3] *Ibid.*, pp. 179-180.

sharply for his failure to meet the production standard. The modern version of the plan guarantees base earnings. It becomes similar in effect to the Gantt Task and Bonus Plan. The differential piece-rate method has a high incentive value. It may therefore be difficult to introduce. Considerable time may be required to train the average employee to maintain the standard of production continuously without excessive effort.

The Gantt Task and Bonus Plan

This plan was devised by H. L. Gantt, one of Taylor's early associates in the development of scientific management. Mr. Gantt varied the details of his plan to suit the requirements of specific situartion. The essentials of his plan were as follows: The employee's base hourly earnings were guaranteed for performance below standard. He began to earn "bonus," or "premium" earnings when his performance equaled or exceeded the standard production rate. This bonus was a percentage of standard time, valued at his hourly rate. The standard time per piece, or standard quantity of work, was determined by time and motion study. The actual time taken and the standard time allowed for a job are identical at standard production. The bonus percentage was varied by Mr. Gantt with the conditions of work. It was usually 20 percent, however.[4] We shall assume that it is 20 percent in the following example. The operative, whose base hourly rate is \$2.00 per hour, would receive \$16.00 for a standard 8-hour day, if his rate of production were below standard. He would receive, at standard production

$$\begin{aligned} E_s &= \text{Standard earnings} \\ &= 8 \text{ hr} \times \$2.00/\text{hr} \times 1.20, \text{ or } \$19.20 \\ R_a &= \text{Actual hourly rate} \\ &= \$19.20/8 \text{ hr, or } \$2.40 \text{ per hour} \end{aligned}$$

He would earn at a higher hourly rate above 100 percent productive efficiency. For example, at 115 percent,

$$H_s/H_a = (\text{Standard hr allowed})/(\text{Actual hr taken}) = 1.15$$

For a job whose standard time is 8 hours,

$$H_a = 8/1.15, \text{ or } 6.957 \text{ hr}$$

The employee would be paid standard time for the job, or

$$E_s = 8 \text{ hr} \times \$2.00/\text{hr} \times 1.20, \text{ or } \$19.20$$

[4] *Ibid.*, pp. 185-200.

But he takes only 6.957 hours to complete it, actually. His actual hourly rate therefore is

$$R_a = \$19.20/6.957 \text{ hr, or } \$2.76 \text{ per hour}$$

The increase in his rate of earning, over base, is ($2.76/$2.00 × 100) or 138.0 percent.

It is evident that this plan also has a high incentive value and hence may be correspondingly difficult to install. However, it is simple, and therefore easily understood. It precludes low wages resulting from failure to meet production standards, by guaranteeing base wages.

The Bedaux Plan

The Bedaux plan was developed by Charles E. Bedaux, an industrial consultant. It has been used in many companies in this country and abroad. The essential features of the Bedaux plan are as follows.[5] The standard time for a job is determined by time and motion study. Each minute of allowed time is called a point, or B; thus there are 480 points in an 8-hour day. The number of standard points allowed for a particular job is shown on the employee's work ticket. The value of each point for the employee is his hourly rate divided by 60. In order to know how much he has earned in a day, the workman has only to total the number of points allowed on the jobs he has completed, and multiply the total by the value of his point. An employee who has a base rate of $2.00 per hour would have a standard point value of ($2.00/60), or $0.0333 per standard minute. He has been described as an average employee for this class of work, under the previous definition of the term. He therefore should produce approximately 576 points of work per day, since the incentive rate is 120 percent. He would earn then, at standard production, at the rate of $19.20 per day, or $2.40 per hour. Base earnings are guaranteed under this plan, as in other modern plans.

A certain percentage of the workman's incentive earnings is sometimes deducted as a bonus for the foreman in the belief that the employee's ability to earn incentive wages is dependent to a great extent on the managerial ability of his department head. This feature has been unpopular with the operatives, and has been discontinued in many concerns. It is usually better to have a separate incentive plan for operative executives that is suited directly to their management problems.

The Bedaux plan has certain advantages. For one, most classes of operative employees can readily understand it. They can compute their

[5] *Ibid.*, pp. 224-245.

earnings easily. The clerical expense connected with it is greater, because of certain control features of the plan, but not enough to constitute a serious objection. Inasmuch as performance is measured in units of standard time, it is possible to compare the productive efficiency of different jobs or departments. The plan should be easier to install than some of the preceding plans, but incentive value is not as high.

Group Incentive Plans

In many types of work, men work in groups. Production is the joint product of the group. Therefore group rather than individual incentives must be offered for increased performance. The better-known plans for this purpose are group bonus, group piecework, and group day work with production standards.

In each of these plans, a group standard for the job is usually set by time and motion study. The work done by an employee member of the group on his operation or phase of the job is analyzed to determine the time required for it. The group standard time is the sum of the times allowed for the completion of the particular product item. It is assumed that 5 operations are required to machine a certain component part of a product. The job has been conveyorized for straight-line production. There is one employee for each operation. The standard time allowed for each operation is 30 minutes. The standard rate of production, then, is 2 pieces per hour. The flow of work is in balance, obviously, as individual pieces move through the first operation to the fifth and final operation. The group time allowed for the completion of each piece is 150 minutes, or 2½ standard hours per piece. This group standard time is so set that the group should produce at the rate of 120 percent of standard. The group should turn out per standard day, then, an average of (2 pcs/hr × 8 hr/day × 1.20), or 19.2 pieces per day. The standard time allowed to this group for the week, assuming production at the standard rate, would be (96 pcs/wk × 2.5 hr/pc), or 240 group hours for the week. This group clocked 200 attendance hours, since it worked a straight 40-hour week. It earned, therefore, a total of 40 bonus hours. A group bonus plan usually applies the group efficiency rating, in this case 120 percent, to the base earnings of each employee. An employee whose base hourly rate is $2.00 per hour would average $2.40 per hour under the above conditions, as before. A change in an employee's base rate does not affect the earnings of other members of the group.

The group production standard can be set up in the form of a group piece price. The group piecework earnings for the period are split among

its members in proportion to their base hourly rates. The clerical expense of group piecework should be somewhat less than that of group bonus. A change in the base rate of a group member will affect the earnings of other members, however, unless the group piece price is adjusted.

Group day work with production standards is similar, except that no direct financial incentive is offered. Production is sustained by the incentive value of definite objectives, the mechanization of work such as conveyorized production, and executive supervision. The exercise of authority and the fear of losing one's job become more important; these are negative incentives that tend to depress morale unless handled carefully. Plans of this kind have been introduced in many mass production industries. Their introduction has been due, in some cases, to union opposition to incentive plans. Such plans have a lower incentive value than group plans which offer a direct and immediate financial incentive. Plans of this type are frequently called "measured day work."

Group incentive plans are quite satisfactory when the coördinate or successive phases in a job are manual or hand machine operations. These should be directly and immediately dependent on each other. In a production line, for example, each operation immediately follows the preceding one and depends on it directly for a supply of work. In many cases, these operations are unified physically by conveying machinery. The men can determine who, if anyone, is holding up production, and can exercise self-discipline, thus reducing the necessity for the foreman to use his authority. The operating cost of group incentive plans is much lower than individual incentive plans. On the other hand, attempts to introduce a group bonus plan with groups doing similar rather than complementary operations—for example, a group of drill press operators in intermittent manufacturing—have been generally unsatisfactory; in some cases, production has decreased rather than increased. It is probable that group incentives would have little effect on completely automated production.

Regularized Employment and the Guaranteed Annual Wage

Loss of employment and wages has many serious consequences. It forces the employee into debt. It may disrupt his family and social life. Such wage loss may have other undesirable results.

Economists frequently make a distinction between "money wages" and "real wages." The former are merely the number of dollars of current purchasing power that the employee gets in his pay check. This purchasing power is relative to that of the dollar in some base period. It is measured

by some price index. We are talking, at the moment, about "60-cent dollars" and "50-cent dollars." It is hardly a "25-cent dollar," if one goes back to the beginning of the 19th century. The value of the dollar varies with monetary inflation, of course. A general reduction of employee hourly wage rates, during a business recession, does not lead necessarily to a reduction of employee purchasing power, provided that there is no substantial reduction in his real wage rate. Our economy, on the other hand, has become dependent on installment credit to maintain production and consumption in many business fields. The employee must make his installment payments, during a depression, with dollars of higher purchasing power. This does reduce his purchasing power, obviously. He works fewer hours during a depression, furthermore. There is a political danger that a frustrated working population whose morale has been broken by long unemployment, will accept, in desperation, the apparent cure-alls of socialism. There are many other reasons why the public has an interest in a stabilized economy, and in the maintenance of employee purchasing power.

The employer has an obvious interest in stabilized operations and regularized employee earnings. A successful plan should theoretically give him better labor relations. There should be less employee restriction of production, as a result of it. Better employee coöperation generally should result also. There should be fewer disciplinary problems, and other advantages. It has worked out this way in some cases, but not always. The employer may get the greater effectiveness that comes from a stabilized organization. He should get the relatively lower costs and capital absorption that comes from stabilized operations.[6] The certain costs of operating the plan must be set against the uncertain advantages that may flow from it.[7] There are intangible employer values which cannot be costed, of course. For example, many employers appear to have derived considerable psychic satisfaction by developing a plan for regularizing employment and employee earnings. All employers do not oppose such plans. They do oppose violently governmental or union compulsions to guarantee employment or wages. Their reasons will be seen shortly.

Many people think today that the movement to stabilize employment

[6] The term "stabilized," as used here, does not imply a static situation. American management wants a dynamic balance in forward motion. It does not want a static balance.

[7] An excellent research study of guaranteed wage plans and their costs was made by Dr. W. E. Schlender of Ohio State University. The results will be found in an unpublished dissertation entitled "An Investigation of Certain Basic Management Problems under Annual Guarantees of Employment and Wages," 1955.

and maintain employee income was begun by labor leaders. It was initiated actually by employers. Some management-sponsored plans antidate considerably the 1929-1932 depression, the New Deal, and the Wagner Act. The Proctor and Gamble plan for guaranteed employment is a well-known example. The history of management-sponsored plans goes back to the beginning of the century, as a matter of fact. Some of these plans were an outgrowth of depression experiences, nevertheless. The Nunn-Bush plan for regularized earnings is an example.[6] There are others. The Fair Labor Standards Act of 1938 made provision for relief from payment of time-and-one-half for overtime, provided the company agreed under union contract to furnish 1000 hours of work in 26 consecutive weeks or 2000 hours in 52 weeks. A proposal for guaranteed annual wages was made to the steel industry by the United Steel Workers-C.I.O., in 1943. This was referred to the National War Labor Board in 1944. A proposal for "A Guaranteed Wage Plan for the Workers in the Steel Industry" was presented to the U.S. Wage Stabilization Board in 1952. It called for a 52 week guaranty for eligible employees. The C.I.O. Electrical Workers asked the Westinghouse Electric Corporation, in 1954, to guarantee its employees an annual wage equivalent to 40 hours pay for 52 weeks of the year. A similar demand was made later on General Electric. None of the above union-sponsored proposals resulted in a guaranteed annual wage plan. The C.I.O.-Auto Workers negotiated a contract with the Ford Motor Company, in June 1955, that has been called a G.A.W. plan. Company spokesmen have denied that it is a company guarantee of annual wages. It should be noted that no company ever has guaranteed to its employees the equivalent of 52 consecutive weeks of work at a stipulated hourly base rate. It is the contention of opponents of G.A.W. that no company ever could. It is reported that more than 100 companies signed "Ford-type" contracts within a period of 6 to 9 months following the signing of the Ford agreement. A brief summary of the plan is necessary because of its importance.

The so-called Ford-type plan is a plan for supplementary unemployment benefits. The employer pays a stipulated amount per hour, usually 5 cents, into a trust fund. These plans are intended to provide private supplementation of state unemployment benefits. The amount of supplementation depends on the provisions of the plan. The Ford and General

[6] This plan was adopted in July, 1935, after previous employee acceptance by secret ballot. The plan grew out of predepression employer-employee experiences and relationships, however. The company had no union contract at the time. See *The Nunn-Bush Plan—Fifty-Two Pay Checks Each Year*, published by Nunn-Bush Shoe Co., in October 1936.

Motors plans provide that the cash benefit payment, when combined with unemployment compensation, may not exceed 65 percent of the employee's take-home pay for the first 4 weeks of unemployment, and 60 percent of such pay for the remaining 22 weeks. The American Can Co. has agreed with the United Steel Workers-C.I.O. for 65 percent of take-home pay for 52 weeks. These plans usually include some provision for restricting eligibility to participate in benefits. The restrictions are based chiefly on length of service. The activation of these plans has been conditional on rulings by the U.S. Commissioner of Internal Revenue on certain tax aspects of employer contributions. It depends also on rulings by the Administrator of the Fair Labor Standards Act that a company's contributions are not a part of the employee's regular wages. It requires changes in state laws or rulings by state attorneys-general to permit the integration of private and public compensation. The Ford plan, for example, does not go into effect until the states that have two-thirds of Ford employment have accepted the integration principle.

The probable effects of such G.A.W. plans cannot be evaluated at this time. However, some of the objections that have been raised by employers can be pointed out. There is some fear that G.A.W. would introduce further rigidities into our wage rate structures. It would probably support wage rates and slow down their adjustment during depressions. Cost rigidities may accelerate a business decline. The break-even point of a company with such a plan would be increased. The employee's incentive to save would be reduced. Such plans may lead to "co-management," syndicalism, and socialism. Anything that affects the volume of sales usually affects employment. The employee has less incentive to seek new work during a period of economic adjustment. The expansion and growth of business may be discouraged. New employees mean an additional compensation liability. Such plans may lead to employee domination by union leaders, when they control the reserve funds and the operation of the plan. They may lead to further control of business in the hands of large corporations, because small companies may be unable to stand the expense. Union-employer lobbying could be expected to get increases in the scale of state unemployment benefits and the length of the benefit period. Some of these objections appear to be difficulties that could be overcome. On the other hand, the record of G.A.W. plans has been poor in the past. Most of them have been in small companies, such as marketing establishments or manufacturing companies making consumers' goods. The mortality of these plans has been high, due usually to financial difficulties. The history of G.A.W. suggests, nevertheless, that the practice

of stabilizing employment and wages probably will be extended. This has been recognized by employer spokesmen.[9]

The methods of stabilizing income or employment fall into two categories: those that tend to overcome seasonal variation in sales, employment and wages, and those that tend to overcome cyclical variation. The promotion of off-season sales through price discounts tends obviously to overcome seasonal variations in demand. The development or acquisition of complementary product lines, with different seasonal sales peaks, is another. Some manufacturers are able to manufacture to stock at a fairly constant rate. Other methods for coping with seasonal variations have been used. There are fewer means for overcoming the effects of cyclical variations in employment and earnings. The establishment of financial reserves from which deferred wages can be paid during periods of unemployment probably is the most practicable. The payments must cease when the reserves have been used up, of course. Savings and investment plans have been used also to aid the employee in building his own financial reserves. The withholding of technological improvements has been suggested. Better long-range planning by executives of capital investments for company growth and expansion would be helpful certainly. No doubt other means will be found.

More space may have been devoted to G.A.W. than is warranted in a general book on the subject of management. It may be justified, however, by the difficulties with this problem that are anticipated in the immediate future.

Employee Service and "Fringe" Benefits

The payments to labor in the form of wages have been increasing at approximately the same rate as *per capita* productivity. The percentage ratio of these payments to gross annual product has been practically a constant figure. Real wages have increased, of course, because of price stability and better quality of products. This situation has been about the same for union and nonunion employees.[10] Such statements do not indicate the increasing importance of fringe benefits in recent years, however. These benefits have accounted for an increasing proportion of the total values that are received by the employee through employment.

[9] The National Association of Manufacturers has made some suggestions for a "Sound Approach to Greater Employee Income Security" in a special Employee Relations Division report entitled "*GAW, SUB . . . or Income Security for Employees*," Nov. 9, 1955.

[10] A summary of the supporting data was published in the December 1953, issue of *Economic Intelligence*, by the Economic Research Department of the Chamber of Commerce of the United States.

These may be defined as any economic values that the employee receives in addition to wages, hours, and working conditions. Many concerns prefer to use the term "employee service" in referring to plans for providing such fringe benefits.

These plans can be classified according to the groups that are benefited. There are plans for executive employees, and for operative employees. Plans for executives may serve administrative executives or operative executives. The needs of the two groups are related but different. Fringe benefit plans for administrative executives are effects, in large part, of confiscatory income tax rates in the high-income brackets. Many of them seek to aid the executive legitimately in his efforts to keep a larger proportion of his earned income. Some of the more common plans are as follows: (1) *Stock option plans,* in which the executive is given a contract to buy a certain number of shares of the company's stock at a stipulated price, at any time during a stipulated period of time. He pays only a capital gains tax when he exercises his option and sells his stock. (2) *Deferred salary plans,* in which a stipulated salary per annum is for the life of the contract. This life extends beyond the normal retirement age of 65. (3) *A consulting contract* may be given to the executive. It usually calls for a stipulated minimum monthly retainer fee for a stipulated period of years following retirement at age 65. (4) *Pension plans* that will enable the executive to continue his standard of living beyond retirement. (5) *Company-paid insurance programs* that assure an adequate estate for the executive's wife and family. (6) *Deferred bonus plans* voted by the company's board of directors in accordance with its usual policy and procedure. Payments are made in installments over a period of years, to reduce the executive's annual tax liability. (7) *Generous personal expense accounts,* that take care of a good share of the executive's normal living and vacation expenses. The executive's salary is no longer a measure of his remuneration. The intent of such plans is to tie the executive to the company and retain the use of his services. Executives in concerns that do not have such plans sometimes take early retirement. One hears also of executives who turn down a job of greater executive responsibility, at a higher salary, because the tax collector takes too big a slice of the increase. It has been alleged that the tax situation reduces the incentive for subordinate executives to develop themselves for top leadership positions. Executive development programs have become almost mandatory. The decreasing executive mobility is a cause, as well as the rapid growth and development of the industrial organization. Fringe benefits for general executives have become necessary for such reasons.

Service plans for operative employees also can be grouped into two general classes. Some provide primarily an opportunity to obtain certain economic benefits in addition to wages, hours, and working conditions. Others provide primarily an opportunity to gain certain intangible noneconomic values through association in social activities. An examination of the contents of the "packages" that are being negotiated by union leaders will show usually a number of demands for new fringe benefits or increases in old ones. The cost of the benefits is usually stated in terms of cents per hour. It is sometimes greater than the cents per hour of wage increases that are demanded. Some idea of the importance of these benefits is given by their costs, which have been increasing steadily. These costs are now somewhere between 20 and 25 percent of the payroll, for the average company with a well-developed employee service program. A plant with 1000 employees, for example, might have an annual payroll of $3,750,000 and a bill for fringe benefits of $750,000 or more. All costs are borne eventually by the customer, rather than the employer, of course.

Most fringe benefit plans for operative employees were developed and introduced initially by management. The courts have ruled that such benefits may be a consideration in the contract of employment, and are bargainable accordingly. Yet executives have opposed the requirement that they bargain with labor leaders over fringe benefits. Many of the reasons have been discussed previously. The original intent of many employers was to improve organizational morale. It was hoped that an integration of organizational and personal interests could be accomplished by helping employees to gain certain values that are associated with employment, but are not regarded usually as a part of wages. The desire for economic security includes one set of such values. Management has objected, in the past, to bargaining over fringe benefits for several reasons. It increases, rather than decreases, the difficulty of developing and maintaining good organizational morale. The union gets the credit for any increased benefits, since it makes the demand, although the plan may actually have been initiated by management. A union leader can always demand more than the company offers, or can afford. Management is placed in a position of opposing the employees' "rights." A union is a political organization. Its officers hold office, theoretically, by the suffrage of union members. This is not always the case, however. The direction of benefit costs is always up, as in the case of any political organization. These and other management objections are now matters of academic interest chiefly, since the bargaining question has been resolved by judi-

cial fiat. They have practical significance nevertheless, in so far as they throw light on recent management policies in the field of employee service.

The tendency of industrial leaders to take the initiative in the development of employee service plans has been noted previously. They are communicating directly with their employees concerning the nature and operation of such plans. They try to make the best offer that they can, in bargaining with union leaders, and to stick to the offer. Other policies were noted in connection with collective bargaining. The following policies were not: The plan should benefit a substantial number of employees. It should satisfy some real need or desire. Anyone usually will accept something for nothing. Giving someone something that he does not want, at no cost, will not improve morale. The principle of sacrifice applies in morale development. It is recognized that company-paid programs are popular at the moment. Executives are able to retain a larger measure of control of them. The principle of participation also applies: the greater the number of employees who participate actively in the activity, the more likely is the plan to get employee understanding, acceptance, and support. It is their activity, when the employees run it in coöperation with management. It is obvious that no paternalism should be involved in the operation of the plan. Most people appreciate being helped to help themselves, when they ask for it. They do not like being told what is good for them, even though it is the right answer.

The activities that are included in an employee service, or fringe benefit, program vary between companies. The program content depends on the size and financial resources of the company, industry practices, the attitudes of the company's general executives, the needs of the particular employees, and other considerations. The following tabulation lists the principal areas of employee service activities in a nationally known organization.[11] It is believed to be a typical case example, in so far as the general types of activities are concerned. The relative financial importance of each area is indicated in terms of the percentage ratio of service

[11] This tabulation is based on the company's employee benefit costs report for 1955. In this report, payroll expense includes straight time and cost-of-living adjustments, but not overtime. "Health and welfare" includes employee retirement, group insurance for life, hospital and medical benefits, and sick leave payments. "Legally required benefits" include social security, unemployment compensation, and workman's compensation. "Payments for time not worked" include paid vacations, holidays, rest periods, etc. "Miscellaneous benefits" include quite a number of activities, such as medical services, suggestion awards, educational assistance, the Activities Association, credit union, cafeteria, and others. This is a young organization. Its retirement costs are low. Its management expects total benefits costs to approach the national average gradually.

cost to payroll expense. These percentage ratios are not necessarily typical.

Class of Activity	*Percentage of Cost to Payroll Expense*
Health and welfare benefits	4.73
Legally required benefits	2.58
Payments for time not worked	10.56
Miscellaneous benefits	1.50
Direct administrative expenses	0.02
Total cost of employee benefits	19.39

Any thorough discussion of employee service activities must be reserved for texts in the field of personnel management. A few typical examples of fringe benefit plans will be discussed briefly.

Group Insurance Plans

The more common forms of group insurance plans are group life, group annuities, group health and accident, and group hospitalization policies. In some instances, the company pays the full cost of the insurance premium. Some companies require the employee to pay part or all of this cost. Participation in contributory plans is of course voluntary. As a rule, the personnel department acts as a service agency, keeping the necessary records and handling premium payments, claims, payroll deductions, etc., without expense to the employee. When the company contributes part of the premiums it should be represented in the management of the plan to protect its investment. Employee representation is equally important.

The purpose of group life insurance is to provide funds at the death of the wage earner, which will help hold the family together until it has adjusted itself to its changed economic condition. While the amount received in any particular case is not sufficient to continue the wage-earner's income, it usually aids materially in defraying funeral expenses. It may save his dependents from actual want. The amount of insurance that the employee can take out usually depends on his length of service with the company or the amount of his wages or salary. Group life is a form of term insurance, and has no cash surrender value. It affords the employee much cheaper protection than he could buy as an individual; as a matter of fact, it is often the only life insurance that he can afford. Under some plans, a group policy is convertible into a straight life insurance policy if the employee leaves the company, but his premiums increase to those for his age group.

Many concerns formerly had private pension plans for their employees.

Some of them are still in effect. Today, however, a concern which wants to provide pensions usually does so under a group annuity plan. The objective of such a plan is to improve morale through the provision of a certain measure of security against old age. The employee's eligibility for a pension usually depends on two factors: the length of his continuous service with the company, and his age. In most cases, he must have worked continuously for a period ranging from 20 to 25 years, and he must be 60 or 65 years old. The amount of his pension may be determined on the basis of his length of service and his average earnings over a given period. For example, it may be a certain percentage of his average annual wages for the past 5 years, multiplied by the number of years with the company.

Group health and accident policies offer protection to the employee against loss of income because of sickness or injuries not resulting from employment. They provide that, after a brief waiting period, he shall receive a fixed percentage of his weekly wage each week for a stated number of weeks up to a maximum. His doctor's bills may be paid up to a certain amount. Surgical and hospital expenses are usually covered under a separate contract.

The national and state social security laws have in some instances affected the management's policy with regard to insurance and pension plans. Some concerns have modified their private plans. They have reduced their expense in proportion to the increased taxes under these laws.

Savings and Investment Plans

Some executives believe that the thrifty employee is more stable, dependable, and satisfied. They have formulated plans that foster habits of thrift and aid their workmen to build up a backlog of savings. On the other hand, the current generation of workmen, between the ages of 25 and 40, have had no experience with a major depression. Many of them have been indoctrinated with a philosophy of "dis-saving." They have been convinced that "the government can't permit a depression," and can prevent one. Everyone hopes, of course, that they are right. They have embraced the installment contract that requires little down payment and too long to pay. Many of them make little attempt to save. Yet these savings and investment plans still exist. This may be due, of course, to the persistent stubbornness of some "unreconstructed" top executives who have failed to recognize the omniscience and omnipotence of govern-

mental executives. It may be worth while, nevertheless, to comment briefly on such plans. They could become stylish again.

As is true of most service activities, participation in a savings plan is voluntary. Any employee who elects to join it must deposit a small percentage of his salary each week. The decision as to the actual amount rests with him. The amount that can be deposited during a given period may be limited to prevent oversaving, and to limit the company's liability. The company guarantees the employee a certain rate of interest. It is usually higher than he could get in a savings bank. It may also credit his savings account with an amount equal to a definite percentage of his deposit; for example, he may be credited with an additional 50 cents for each dollar that he deposits. He may withdraw his own savings with interest at any time, but not the company contributions unless they have been on deposit for an agreed length of time. If he closes his account before this time, this balance accrues to the benefit of the other members of the plan. The employees should be represented in the management of the savings funds.

The stock sales plan, another type of thrift plan, facilitates the purchase of the company's stock by employees. It is intended to promote thrift and increase their interest in the company's success. Such a plan must be supported by a continuing communications and educational program to be successful. The stock frequently is sold to the employee on an installment plan. The dividends paid on the stock offset the schedule of payments. There has been a substantial increase in such plans in recent years. The motives of management have been less a desire to promote thrift, probably, and more a desire to promote an understanding of the company and its management problems. There is no doubt that some executives have been motivated by a generous desire to enable employees to share in profits as owners. The desirability of such plans is questionable, nevertheless. Employees are not usually in a position to accept the financial risks of ownership.

The Credit Union

The credit union is not a new idea. It has attracted considerable attention, nevertheless, because of its rapid spread. Employees may be faced with wage garnishments when they are unable to pay their bills, as a result of unemployment and too many installment contracts. They may be forced to borrow at usurious rates to meet financial emergencies. Financial worries cause a serious loss of morale among individual em-

ployees. The credit union provides a satisfactory and effective method whereby employees can help themselves in matters of personal finance. For this reason, companies often take an active part in their formation. Today there are credit unions in thousands of business concerns throughout the country.

A credit union is a limited banking institution organized for the purpose of making small character loans to its members. It is designed to aid people in the lower-income groups who would ordinarily be unable to get such loans at a commercial bank. It may be organized under either a state or a federal charter. It is subject, in both cases, to governmental banking supervision. Its officers are elected by and from its members. The company may assist in the initial organization of the credit union and may provide office quarters, etc. The personnel manager may be a member of its board. The management of the credit union should be completely divorced from that of the company, however. It should be wholly in the hands of its members. As a rule, membership in industrial credit unions is limited to the employees of a company. It requires the purchase of at least one share of stock, which may be paid for in easy installments. There is generally a maximum rate for dividends on the stock, varying from 5 to 8 percent in the different credit unions. The funds are usually held in a commercial bank. Loans are limited to some maximum amount. They are made only to members. The usual interest rate is 6 percent on the face amount, which is the equivalent of 12 percent per annum. There may be no service charges.

Credit unions have had a surprisingly small percentage of losses, The borrowers are fellow employees whose habits and reliability are known, personally, to the officers of the credit union. Moreover, the borrower knows that he is using the savings of his fellow workers. Repayment is a matter of honor. His group may exert social pressure if he defaults. In many cases, credit unions have been of great service in effecting agreements between employees and their creditors. They have made loans to consolidate and discharge these obligations. They have helped the employee to budget his income, etc. Such services would subject any management that tried to offer them to charges of paternalism.

The Employees' Association

The mutual benefit or employees' association was originally a device to furnish certain forms of private social insurance. It may still afford a measure of protection against loss of wages in case of disability. It

may provide the employee's funeral expenses. The company may provide such benefits today through some form of group insurance. These associations frequently carry on extensive social and recreational programs. Such functions have tended to become the most important reasons for the association's existence, because of the great growth and extension of private and public social insurance. The character, size, and social needs of the community are factors affecting the content of such programs, of course.

Employee Housing

A rapidly growing plant in a small manufacturing community may find it necessary to bring in considerable additional labor. A workman who cannot obtain decent housing and satisfactory living conditions at a reasonable cost may move at the first opportunity to another town where these necessities are available. The result of poor employee housing may be unsatisfactory home conditions, loss of self-respect, lowered morale, dissatisfaction, and high labor turnover. The problem has important current significances. Many large growth companies have been establishing branch plants at strategic locations throughout the country. There has been some migration of companies from urban or eastern locations. It has been alleged that too many operative employees have bought homes at higher prices than they can afford. They have done so on the basis of insufficient down payments and overgenerous payment terms. This could cause trouble when, as, and if we have a recession. A domestic condition that lowers the morale of individual employees generally may be reflected in a deterioration of organizational morale and labor relations within the company.

Large companies create separate housing corporations. They survey local housing conditions to determine the availability of proper housing. They determine the character and extent of employee housing needs. They may work out plans for the easy purchase of homes, and supervise the financial and construction details. The housing corporation's services are provided at cost. The policy of most manufacturing concerns is to relieve a critical housing condition, assure the sale of houses to its employees at fair prices and terms, and get out of the housing business at the earliest possible moment. Company operation of company-owned homes does not usually improve labor relations. The application of any such policy must be subject to the limitations of the company's financial resources, of course.

Recreational and Social Activities

Recreational and social activities make it possible for the employee to obtain a number of noneconomic but extremely important benefits. These activities enable him to enjoy a variety of entertainment at little expense. Such benefits satisfy also the almost universal desire for competitive play in some form. They supply him with outside interests that add to his enjoyment of life. It is the company's intent to create a social life centering in the plant that will make the company definitely a better place in which to work. If properly handled, such activities offer opportunities for coöperation in which the danger of friction is at a minimum.

The effectiveness of such activities as focal points for common interests in the organization varies between urban and country locations. The city's well-organized forms of recreation and entertainment can compete successfully with any similar programs offered by the company. Furthermore, the employees may be scattered over the entire city. They may have little desire to return to the plant after working hours for any kind of recreation or social entertainment. In the country, on the other hand, the company may be forced to undertake an extensive program to provide these activities because the community itself cannot. In most cases, therefore, the program will be different, and probably more limited, for a city concern than for a country concern.

A recreational program, in any case, should be financed, organized, and run by the employees as far as possible. After its initial organization has been completed, the management of the company should provide only such advice and assistance as may be requested.

As a rule, the management prefers to coöperate in those activities in which the largest number of employees can participate, and in which everyone from the president to the yard laborer can take an interest. Intramural sports are such an activity. The differences in the social and recreational interests of the men and women workers must also be considered.

Recreational activities may be classified, on the basis of participation, into two groups: those which offer active participation to a large number of employees, and those which offer no actual participation but an active interest. The first class includes company picnics. Dances, card parties, and similar social activities may be effective when sponsored by an employees' social organization. In the purely recreational field, interdepartmental bowling leagues are popular among employees. The International Business Machines Corporation has three employee-managed clubhouses, located at Endicott, Poughkeepsie, and Sands Point, New

York. The Endicott clubhouse has 16 modern bowling alleys, where more than 124,000 league and open-play games were bowled during the 1955-1956 season. These facilities are shown in Figs. 26.1 and 26.2. The second class includes those activities that have common interest values, but do not require personal participation generally. The National Cash Register Company, for example, gives motion picture shows in its auditorium for its employees. Interdepartmental or divisional softball leagues,

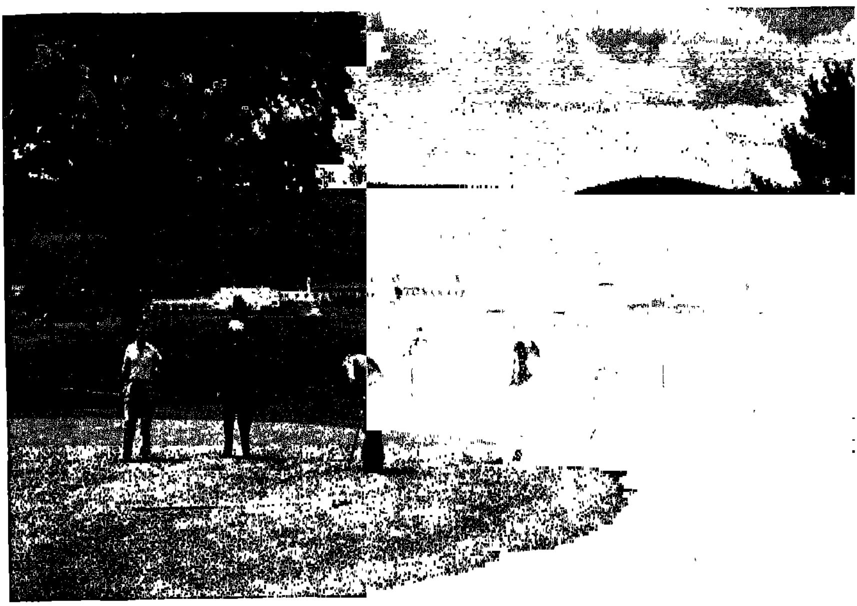


Fig. 26.1. The IBM Clubhouse and Golf Course at Endicott, N. Y. (Courtesy, International Business Machines Corp.)

boxing tournaments, etc., should also be put in this class. Few employees can participate actively, but everyone in the organization can take an active interest. Such activities not only create a community of interests, but may directly contribute to the development of organizational pride. They should not be permitted to become professionalized, of course.

Miscellaneous Service Activities

In addition to the above types of service activities, there are many other miscellaneous ones, such as provisions for company restaurants, company stores, legal aid for employees, employee gardens, vacations with pay for operative employees, etc. Some of them can be classed as either economic or social as far as their objectives are concerned. These are affected by the same service principles and policies that were discussed above.

Working Conditions

The problem of working conditions in connection with plant layout, physical factors of condition, and time and motion study have been discussed previously. The employee and the executive have a mutual interest in them. Promotion, plant sanitation, and other problems that affect the employees' interests have also been considered. Discussion of the economics of morale brought out the fact that any problem that affects the relations between personal interests and company service objectives may affect morale. It is accordingly of interest to the labor relations department.

Fig. 26.2. The Bowling Alleys in the IBM Clubhouse. (Courtesy, International Business Machines Corp.)

Safety and Compensation

Safety is another problem in which the public, the employees, and management are greatly interested. In general, industry is hazardous. Unless management pays close attention to developing safe working habits and providing safe conditions, a large number of serious accidents is inevitable. Estimates of the cost of accidents are necessarily inaccurate,

but they indicate that it is probably between half a billion and a billion dollars annually. While much of this cost falls originally on the employer, it is likely to fall eventually on the employee and the public. The public has a further interest in certain related problems such as the care, maintenance, and rehabilitation of those persons who have been crippled.

Partly as a result of the public interest in industrial safety, all the states now have some form of workmen's compensation laws that cover temporary disabilities caused by accidents or occupational diseases. These laws usually provide payments based on a percentage of the employee's weekly wage; the number of weeks over which these payments extend varies with the nature of the disability. In some states, employers may become self-insurers of their compensation risks. To do this, they must satisfy the state industrial commission of their ability to meet any compensation claims. They must post a bond guaranteeing payment of the compensation determined by that body. Otherwise, an employer usually has to enter the state compensation insurance fund. His premiums are determined both by his class risk (the basic accident risk for his particular industry) and by his individual risk. Merit-rating clauses in these acts provide that if he reduces his accident rate, his premiums will be correspondingly reduced. Hence, in both cases he has a strong incentive to keep his accident rate to a minimum.

The better solution of the safety problem, of course, is the prevention of accidents, rather than the payment of compensation. Compensation costs and a growing feeling of responsibility for employee safety have greatly stimulated employers' interest in the problem of prevention. Moreover, there has gradually developed the realization that unsafe working conditions are bad for business for other reasons as well. As a result, the accident rate in American industry has been reduced, over the years, to a relatively low level in terms of both frequency and severity. Constant study, education, and supervision is required to keep it there, however.[12]

As a result of extensive experience with the safety problem, certain principles for safety in work have become recognized. The first requisite for accident reduction is good working conditions, and particularly good lighting. All accidents should be investigated promptly and fully to obtain the necessary information for the intelligent formulation of safety rules, the study of operations with a view to introducing safety devices, etc. Complete statistics should be compiled on the frequency and

[12] The frequency rate is the number of accidents involving loss of time per million man-hours. The severity rate is the number of days lost per thousand man-hours.

severity of accidents according to kind and department. Adequate emergency medical service must be provided because the prompt, thorough treatment of injuries usually reduces their severity.

The man is usually more of an accident factor than the machine. In consequence, a continuous campaign of publicity and education is necessary. Posters of the National Safety Council will be seen on the bulletin boards in a great many plants. There will also be interesting safety exhibits in various parts of the plant, etc. Such material is changed frequently to keep up the employees' interest. The foreman is the key man in this as in other operative problems. For one thing, accident reduction depends on whether his men are properly trained for their work. Furthermore, his attitude on the subject affects that of his men. Despite the fact that safety rules are made for their protection, the men will often disregard them unless the foreman enforces them through proper disciplinary action. Because the foreman is expected to report unsafe conditions that need attention, training foremen in the principles of safety is usually an important part of a safety program. The interest of both foreman and employee is stimulated by an active interest on the part of the higher executives in this work. They are often asked to speak before divisional or departmental safety meetings. In addition there may be safety competitions between departments for an award usually given to the department that has the fewest number of accidents involving lost time in a certain period. The competition is usually dramatized in some way. No safety program is likely to be effective, of course, unless there is a safety organization in the company that is definitely responsible for it.

Staff responsibility for developing and carrying out a safety program often rests with the safety director. He reports to the vice-president for personnel in Fig. 22.1. His work may have three chief phases: (1) safety engineering, (2) safety education and training, and (3) compensation and claims. Safety engineering has to do primarily with the design and installation of safety devices. It may be done by the industrial engineering division as a service for the personnel division. Certain phases of safety education may require coöperation with the education and training section of the personnel department. Compensation and claims include the investigation and analysis of accidents and their causes. Those who handle this phase must see that all occupational diseases and injuries involving absence from work are reported promptly to the industrial commission on the proper forms, and they must appear before this body in connection with all claims. Progressive concerns do not oppose just claims; to do so would place their management in opposition to the

rightful interests of the employees, a position in which no management wants to be. The way to prevent compensation claims is to reduce the number of accidents; the ultimate responsibility for this falls on the line organization. The safety department's function is to assist the line in discharging this responsibility. The employee himself also has a responsibility to work safely. Thus in many cases there may be a hierarchy of departmental, divisional, and company safety committees, all of which include employee representatives as well as executives. Their work should be tied in with that of the safety director, of course.

Suggestion Systems

A suggestion system usually has as one objective the procurement of employees' ideas for improving either operating economy or working conditions. Another purpose frequently is to unearth complaints that will indicate points of friction or dissatisfaction among the operative force. An important phase of the morale-building process is the discovery and prompt, equitable adjustment of conflicts between personal and organizational interests.

There are certain requirements for the successful operation of a suggestion system. Suggestion boxes should be located at strategic points throughout the plant. Standard blanks should be placed near each box. There should be a definite routine for handling suggestions. A committee should be responsible for giving them fair and impartial consideration. Committee members are selected by the management on the basis of the technical and managerial knowledge needed to appraise and grade the suggestions fairly and accurately. The committee may also include employees' representatives to avoid any charges of unfairness. The suggestions are collected at regular intervals, and are graded by the committee on the basis of their value to the company. Regardless of its value, every suggestion should be acknowledged promptly. The employee who made it should be advised of the action taken on it and the reasons therefor, even if it cannot be used. Unless this is done, the employees may gradually lose interest in the system. An employee must receive some definite recognition for usable suggestions. It may range from honorable mention to a maximum cash award. There is often a definite scale for different grades of suggestions. This may cause trouble occasionally when the award is inadequate for a particularly valuable suggestion. Some concerns pay the employee a certain percentage of the first year's savings from his suggestion, whenever they can be estimated. This may be impossible in the case of some suggestions, such as those for improvements in

washroom conditions. To provide the further satisfaction of public recognition and to stimulate interest in the system, most shop papers give publicity to those who submit outstanding suggestions. Suggestions receiving honorable mention or better should be noted on the employee's service record, for consideration in connection with promotion.

The suggestion system also brings in complaints. Those relating to personal grievances should be referred to the labor relations department rather than the suggestion committee. A satisfactory adjustment of the difficulty should be made through the department head in order to maintain his leadership position. No action should ever be taken by the department head that can be construed as in any way penalizing the employee for making the complaint, for otherwise the flow of complaints will stop. To afford the employee every protection in this respect, suggestion blanks may be numbered serially. A numbered stub is detached by the employee. If he requests, the reply is made to this number.

The Discovery and Adjustment of Grievances

Conflicts of interests will occur despite any analysis of employee interests and attitudes. Changing business conditions alter the relations between personal and service objectives in a company. They may cause conflicts between the personal objectives of the various individuals and groups of employees. Grievances appear to depress morale in direct geometric proportion to the length of time that they are permitted to exist. It is accordingly important that they be discovered and adjusted promptly at the lowest executive level that has the requisite authority and ability. The proper technique for handling grievances constitutes an important part of foreman-training courses. Management depends on first-line supervision not only to handle individual grievances effectively in the first place, but also to keep it informed of any difficulties and irritations that may create friction in the organization. It relies on the foremen or staff department heads to refer to a higher authority any personnel problems that they are unable to handle themselves. They have not always done this satisfactorily in the past. This is one reason for the development of other means of discovering conflicts of interests, such as suggestion systems, company periodicals, employee representation, dismissal interviews, investigational techniques, etc. Nevertheless, the line department head is still the key executive in the problem. Much educational work is being done, consequently, to teach him to handle his morale-building responsibilities more effectively.

Good labor relations requires a mutual understanding of the characteristics and requirements of personal and service objectives. There should be mutual acceptance of criteria of the proper relations between them. This in turn usually involves an exchange of views and opinions leading to the establishment of a commonly accepted body of facts and principles. When personal interests are affected, executive fiat is not a satisfactory substitute for mutual agreements mutually achieved. Various media are available for communication between management and the company's operative employees. Conference is an important method, of course. A distinction should be made between individual and group conferences. Conferences concerning individual grievances will be discussed briefly. Group conferences concerning group grievances were discussed in connection with collective bargaining.

Some concerns follow a definite, long-established procedure in handling conflicts of interests. Most of these conflicts affect one or only a few employees. An employee usually takes up his grievance first with his foreman or department head. The Taft-Hartley Act permits him to do this alone or accompanied by his union representative, as he prefers. The usual grievance procedure permits him to appeal his case to the next higher executive in his chain of command, when he fails to get satisfaction. This may be the shop superintendent, in the case of a shop operative. The employee may be required at this point to present his grievance in writing. A copy should be sent to the personnel director or the labor relation's manager. The labor relations manager is expected to make certain that the employee's interests are considered fully and fairly. He may advise the superintendent to this end. The superintendent has to consider this advice, but he does not have to follow it. This is obviously an application of the principle of compulsory staff advice. Some plans provide for successive appeals, even to the board of directors if necessary. It is probable that the employee can appeal to a plant grievance committee, if he cannot get satisfaction from his superintendent. It does not follow, of course, that he is right because he is still dissatisfied. The membership of this committee in a union shop obviously will include union representatives. It is therefor unlikely that the employee will carry his appeal beyond this committee. Some grievance procedures have provision for appeal to outside arbitration, however.

Grievance procedures are found commonly in both union and nonunion shops. There is little basic difference between them, except for union representation in conferences above the first step. Union agreements frequently specify what the procedure shall be.

Morale Maintenance

The last phases, in our analysis of the morale building process, were the continuous identification of personal interests with organizational interests within the company, and morale maintenance. The first of these is largely a communications and educational problem. It frequently uses company cases to remind both executive and operative employees that a satisfaction of their personal interests depends on a successful satisfaction of customer needs and desires first. All groups within the organization must work together to this end. Morale maintenance is chiefly the continuous work of repairing morale, when changing business conditions or the subversive action of outside groups tend to break it down.

PROBLEMS

1. The company has a system for job evaluation and classification in operation in its plant. This system was planned on the basis of the principles and general methods of approach that are discussed in Chapter 28. It is the policy in this company to pay base hourly wages that are equal to or better than those in the community and the industry. The company has a union shop. Its base rates are established through bargaining with the employees' representatives.
   (a) Where does this leave management in the problem of determining base hourly wage rates? Evaluate the forces and effects in this problem in relation to one another.
   (b) How do these considerations affect the determination of wage incentive rates? Why?
2. The company feels that it is approaching a peak of the general business cycle, and probably the cycle of its industry. It has organized its operations on a two-shift basis where ever it has been practicable to do so. It has not been possible in all departments. It has been necessary, in fact, to work a certain employee for a total of 56 hours during the past week. The employee put in 8 hours of work on Saturday, and 8 hours on Sunday. His base hourly rate is \$2.25 per hour. His incentive earnings during the week were \$18.90. The company pays double-time on Sundays, based on the employee's average earnings exclusive of overtime payments.
   (a) What was the employee's total pay check for the week?
   (b) What were his average earnings per day during the standard pay period?
   (c) What did he earn for his Saturday work?
   (d) What did he earn for his Sunday work?
   (e) Who pays for the excess earnings above normal base and incentive earnings? Does it matter, since we have to pay it anyhow?
   (f) Would it be worth while to list base earnings, incentive earnings, and overtime earnings on the employee's pay check? Why?
3. A certain plan of wage payment provides that an employee is paid for the

time actually spent on a job. He receives a bonus, in addition, if he completes the job within the standard time. This bonus is a percentage of the time actually taken. This percentage is computed by subtracting from the standard time the time actually taken, and dividing this by the standard time. The bonus earnings are the bonus time in hours, multiplied by the employee's basic hourly wage rate.

(a) What principle of incentives does this plan violate? Why?

4. The union has presented to the company during contract negotiations, a demand for an increase in the number of paid holidays from 5 to 6 holidays per year. These are in addition to a schedule of paid vacations for operative employees. This schedule was accepted by the company's management in last year's contract. The management has refused the current demand for an additional holiday for the following reasons: The company's expense ratio is already 88.0% of net sales. This ratio is the highest in the industry. The company has only a 12.0% profit on sales, before taxes, accordingly. The management believes that this profit margin is inadequate for the maintenance of the company's competitive position, and its continued growth. The general breakdown of its total business expense, at this point on its break-even chart, is as follows: factory costs, 76.0%; administrative expense, 2.5%; and selling expense, 9.5%. The foregoing figures are percentages of net sales. Total labor cost, including fringe benefits, is 60.0% of prime cost. The cost of materials and supplies is 40.0%, accordingly. Factory overhead expense, expressed as a percentage of prime cost, is 120.0%. The company's present expense for fringe benefits is 16.7% of its payroll expense. The average fringe-benefits costs for the particular industry are 21.3% of payroll. There are a number of manufacturing companies in the community, where the company's plant is located, that have granted 6 paid holidays to their employees. The number appears to be increasing. The company pays for the equivalent of 2040 hours of time per operative employee per year, including the cost of vacations. The capital turnover ratio for the company is 1.0 turn per year; the average for the industry is 1.3 turns.

(a) Would you or would you not concur with the management that the demand for an additional paid holiday should not be granted?

(b) How much will the additional holiday lower the company's profit margin on sales?

(c) What, in general, should the company do to improve its profit position?

(d) How valid, in any company, is the defense that a legitimate demand by employee representatives cannot be granted because the company is not making money? What are the fundamental significances of such a contention? There have been some cases in which operative employees have accepted a pay cut to keep the company from going out of business. After all, one must eat. Would such a situation change or not change your point of view? Why?

CHAPTER 27

Education and Training in Industry

The Nature and Significances of Education and Training in Industry

AMERICAN industry spends many millions of dollars annually for the education and training of its people. It would not spend large sums of money unless these were important functions. It therefore should be worth while to define education, and tell what is being done with it.

Education may be defined as a process of developing an understanding of some organized body of knowledge. It involves the development of the mental skills that enable one to use this knowledge effectively in problem-solving thought. Both effective thinking and an attempt to apply a logic of effective thinking take place necessarily with respect to those problems that tend to be associated with the particular body of knowledge. An attempt to apply a logic of effective thinking to the solution of problems about which one knows nothing would be futile. It would be psychologically similar to thinking in a vacuum. It would be a low-pressure operation, undoubtedly. A distinction should be made between cultural and professional education. It is found chiefly in the breadth of background that is imparted and acquired. It is not found in any superior ability to engage in effective thinking. The professional man of today must have a good cultural background, as well as a professional education in his particular field of work. This applies to management education therefore. The development of manual skills is usually incidental in the educational process, but not always. Education for certain branches of the medical profession is an obvious exception.

Training may be defined as a process of developing an understanding of some organized body of facts, rules, and methods. This information concerns largely the operative phases of an applied knowledge. Training involves also the development of the manual skills that are necessary for the performance of specific work projects. The emphasis is on manual skills, but mental skills may be important. The skilled toolmaker certainly

is required to use his head. Training is usually conducted on a lower level of mental skill and effort, nevertheless, than is the case with professional education. It is evident that training and education are closely related. They tend to shade into one another.

There has been considerable discussion recently of "levels of thinking." A distinction is often made between routine thinking, problem-solving thought, and creative thinking.[1] One level blends into another, of course, but it is a convenient distinction. Routine thinking is the type of thinking that is done when one makes rule-of-thumb decisions for day-to-day repetitive situations, based on so-called practical experience. It is the level of thinking that is required to follow a set of instructions in performing a routine repetitive operation. Problem-solving thought involves the application of present knowledges to a body of facts concerning known difficulties, to get a solution for current or anticipated problems. It may result in new solutions for old problems. The case method of teaching is helpful in developing mental skills at this level. It is evident that problem-solving thought can lead into creative thinking. There is some question, for this reason, as to the validity of making a distinction between problem-solving thought and creative thinking. There is certainly a level above the case-problem type of thinking, nevertheless. It involves the development of solutions for problems that have not yet appeared. We may have few facts concerning them. The solutions may require the use of principles and relationships that are sensed rather than known. Thinking appears to involve some processes that are carried on by the subconscious mind. This subject gets us into "free-wheeling," "wild-thinking," "brainstorming" techniques for developing new ideas. It is extremely interesting, but far beyond the scope of this book. There is just one reason why the levels concept of thinking has been discussed here: the plane on which an educational or training program must be conducted depends on the thought level on which the participants must work, in using the skills and knowledges that they obtain. If all that they want is some help in handling their day-to-day problems, the program had better be pitched at that level.

Objectives of Education and Training in Industry

The principal values that result from successful education and training are those that result in greater organizational effectiveness. These values are necessarily secondary objectives of the business organization. Staff

[1] An interesting and helpful nontechnical discussion of this subject will be found in the *Indiana Business Review* of February 1956. It is entitled "The Creative Thinking Process," by John F. Mee. The discussion is short, simple, and well-documented.

objectives are chiefly secondary objectives. Any staff department of a business organization may put on an educational or training program in its field, as would be expected. The program should be planned, organized and operated with the concurrence and coöperation of the education and training department. It usually will be a much better program if it is. Organizational effectiveness results from the development of certain organizational attributes. The principal attributes that can be improved through education and training are (1) effective executive leadership, (2) a complement of people who are competent to perform their assigned tasks, economically and effectively, (3) the organizational attributes of stability, flexibility, and capacity for growth, and (4) good organizational morale.

Education and training contribute also to the employee's accomplishment of his personal objectives. Such values are collateral objectives of the business organization, of course. Most people want to know what is going on in the organization, for example. Information concerning the organization and its activities leads to a feeling of "belonging" to the organization. It results in other satisfactions that may be enjoyed by organization members at all levels. The problem of education for morale development will be discussed shortly. Education and training may prepare an employee for advancement in the organization. Training programs give him the satisfaction of accomplishment. He may be able to earn more money as a result.

Organization for Education and Training

The size of the educational organization depends on the size of the company and its rate of growth. Its structural characteristics depend on the nature of the job that it is expected to do. There may be no distinct differentiation of these functions in a small company. It may make some use of outside educational facilities, such as university extension courses. Much of the work of training must be done on the job by department heads. They can expect only such help from the personnel manager as he can give within the limits of his time. His chief contribution may be to help them plan their programs. He may arrange also for the use of such outside training facilities as are available.

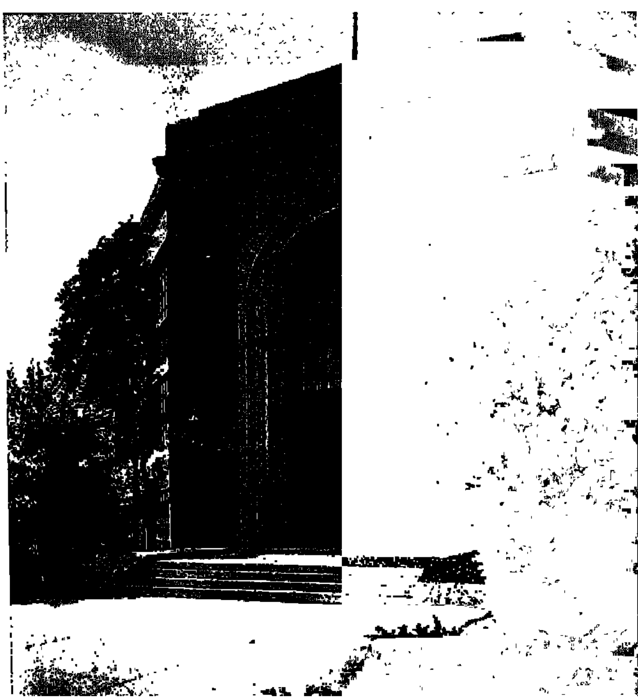
The responsibility for training tends to remain with the employee's superior, as the organization grows. Much of our training results from good direction and supervision on the job. These are important functions of face-to-face leadership. As the organization grows the personnel department gives more training services. It can afford more staff. The personnel

division should be expected only to do the rough training of personnel for other line and staff departments, however. The finish training must be done by the department head and his executive subordinates. It will always be a personal responsibility of executives to develop those employees who are under their command.

The function of education and training is one that can develop through all the stages of staff evolution. A large company may have a department for education and training in its headquarters personnel division. The manager of this department, in Fig. 22.1, reports to a personnel vice-president. There may be training supervisors in the personnel departments of our branch plants. These headquarters training functions may be separated completely from the parent organizations in very large corporations. The General Motors Institute, shown in Fig. 27.1, is a degree-granting educational organization. It is a separate enterprise within the "General Motors Family." It is a wholly owned subsidiary of the General Motors Corporation, with its own president and board. It is obvious that in this case, the functions of education and training have been developed to the final stage of complete staff separation.

It will be necessary to analyze, at least briefly, the general basis for the differentiation, grouping, and assignment of training functions. Their

Fig. 27.1. The General Motors Institute. (Courtesy, The General Motors Corp.)



development can vary greatly between companies and industries. It can vary also with top management's concepts of what an education and training department is and should do.

Functions of Education and Training

The education and training department may offer various programs and services in its field. Their purpose is to assist other departments and divisions in the development of greater organizational effectiveness. A multitude of activities, both managerial and operative, may be found within the business organization. These vary greatly in the kind and amount of work that is required. Figure 6.1 shows the general relations between the principal line and staff functions in an industrial organization. The work of the individual changes gradually from operative to managerial functions as he advances in the organization. The component elements of a company may be located on different service levels. The present jobs of their people may be located in different service grades. The promotional opportunities of these people may differ greatly. It is evident that the various programs of the training department must vary with the needs of the different components of the organization, and their personnel.

It has been noted previously that these programs may be classified broadly as to whether they improve organizational effectiveness generally or specifically. The first category includes educational programs which are designed to acquaint the employee with the conditions and problems of the organization. These programs may be intended to gain understanding, acceptance, and support of company policies. This category may include any programs for morale development. The second category includes various training activities that improve the performance of particular operations or classes of work. They contribute to organizational effectiveness by increasing the effectiveness or individuals or groups of employees. It should be noted also that general executives spend much of their time with problems of planning and organizing. Top management is, or should be, concerned largely with long-range planning. Programs for the field of administrative management therefore tend to be broad, fundamental, and educational. Semiskilled operatives usually perform specific operations, under direct supervision. Programs for the lower operative service levels therefore have to do with training for specific areas of work or particular operative assignments. It is helpful to classify activities in

the second category on the basis of the service rendered. A classification based on Fig. 3.1 can be set up as follows.

A Classification of Individual and Group Training Activities

A. Educational Services for Managerial Functions
  1. Administrative Management
    a. Executive development programs
    b. Understudy programs
  2. Operative Management
    a. Programs for staff operative executives
    b. Supervisory and foremanship training
    c. Executive cadet training
    d. Understudy programs
B. Training Services for Operative Functions
  1. Professional Operative Functions
    a. Company school programs
    b. University extension and correspondence school programs
    c. Planned project assignments
    d. Other methods
  2. Skilled Operative Functions
    a. Apprentice training programs
  3. Semiskilled Functions
    a. Vestibule school courses
    b. Training on the job
  4. Unskilled Functions
    a. Training on the job[2]

There are various educational and training techniques. These will be noted briefly in connection with the above activities. There are other activities in addition to those listed. A brief discussion of those noted above should be sufficient, however, to make clear the responsibilities and contributions of educational and training executives in industry. It may be desirable to discuss first those general educational activities that are designed to develop good morale. We shall then discuss specific services, beginning with those for operative functions.

Education for Morale Development

Our personal interests are associated with those values that satisfy our personal needs and desires. A philosophy of management, life, or any-

[2] This may require a little explanation. No training should be required to be untrained. There are no jobs that are completely unskilled. Any job requires some training therefore. The amount required for unskilled jobs is very little. A new janitor requires some training, nevertheless, if you want a good job of building service.

thing else includes concepts of right and wrong. It indicates basically what is worth while and what is not. It may condition the thinking of individuals, groups, communities, or nations, concerning those values that are desirable and those that are not. All satisfactions of human needs and desires are mental, ultimately. A common philosophy is therefore the basis of a community of interests. Some unity of doctrine is necessary for some required, basic unity of thought. There is some minimum unity of thought that is necessary for satisfactory unity of action. There is always some minimum unity of group action that is necessary for a satisfactory accomplishment of a joint mission. Indoctrination of the rank and file with a sound operating philosophy is a responsibility of leadership in any kind of organization, anywhere. It always has been, throughout the ages, in military, political, and religious organizations. Executives have recognized, in recent years, that this is equally true for the industrial organization. The socialists recognized it long ago, and particularly those exponents of revolutionary socialism, the communists.

Anyone who has read accounts of "educational" activities in communist-controlled countries should have been impressed with the dangers of complete authoritarian indoctrination. These dangers are practically nonexistent in a free economy. They are practically impossible, in fact, so long as we retain the freedoms of assembly, press, and speech. Executives would oppose authoritarian indoctrination necessarily, even if it were possible. The concept of complete, authoritarian indoctrination is incompatible with a free-enterprise, free-market economy. A competitive economy requires the continuous development of new products, new methods, new policies, new organizational relationships, and new approaches generally. The development of new ideas requires something more than stereotyped thinking. It is for this reason that reference was made to minimums, in discussing unity of thought and action.

The general objective of education for morale development is a community of interests. It is accomplished, in part, by developing a common understanding within the organization of the interdependencies of personal and organizational interests. It includes support of the executive in the accomplishment of the organization's primary and secondary objectives. The National Association of Manufacturers has summarized the specific objectives as follows.[3]

[3] This is not a verbatim statement. It is believed to be an accurate statement of the values that the Association regards as important. See *Employee Communications for Better Understanding*, National Association of Manufacturers, p. 8.

1. Employee respect for the capacity and performance of management
2. Better employee work attitudes
3. Greater satisfaction of the individual employee with his job
4. A minimum of work interruptions due to misunderstandings
5. Better management understanding of what employees want and what they are thinking
6. A minimum of misinformation and demoralizing rumors
7. Employee understanding and acceptance of the kind of economic system that we have in America

There is such a thing as an overidentification of personal with organizational interests. The process of identification can be carried to the point where overemphasis exaggerates the importance of personal interests within the organization. The success of an organization requires a reasonable willingness on the part of members to subordinate their personal interests to that of their organization. We have noted previously the principle of the primacy of service objectives, as it applies to the business organization. Overidentification leads to a violation of this principle.

Sound policy rests on sound principle. Sound policy governing morale education rests on the principles of indoctrination. Any statements by the leaders of a business organization must be objective and factual, for example. This is morally sound and practically necessary. One's employees can always apply the pragmatic test of results to one's statements over a period of time. The techniques of the half-truth and "the big lie" can be used successfully, sometimes, by the opponents of industrial leadership, who have no responsibility for the particular company situation. There is a principle of doctrinal prestige: a doctrine may be correct. It is not likely to be accepted by the rank and file, nevertheless, if it is held in low esteem because of some misapprehension. An example is the negative attitude of some employees, in some companies, toward high individual productivity. There are some principles of counterindoctrination that should be understood by industrial executives. Some recent surveys have indicated that the executive's concepts of the free enterprise system and those that are taught in some of our secondary schools are not always identical. Union organizations carry on extensive educational activities. The management of a company should recognize that its ideas may be in conflict with those of the rank and file in its organizations. Its educational activities are counterindoctrinative, whether or not its ideas are sound. There are many other principles of indoctrination.[4] The principles in a policy statement may be expressed or implied. They should be supported,

[4] See R. C. Davis, *The Fundamentals of Top Management*, Harper & Brothers, 1951, p. 593.

in any event, by statements of rules. The latter clarify the intent of the policy. They direct its application. They lead to the development of procedure. The National Association of Manufacturers, for example, offers certain rules for operating a communications program.[5]

1. A good communications program is a "two-way street," constantly concerned with finding out what employees think as well as getting to them what management thinks.
2. The maximum coöperation of and constant participation by top management are required.
3. Front-line supervision should be regarded as the most effective channel for getting information to and from employees.
4. The Company's own operations offer the best and most fertile source of convincing information as to the operation of the private enterprise system.
5. The most effective material is that which the employee can recognize as affecting him personally.
6. Employees resent being "talked down to." A good program will respect their intelligence.
7. People absorb only a relatively small amount of information at one time. Focus the facts on a specific issue at a time.
8. Where feasible, one top executive should be assigned the responsibility for the program of employee communications.

The function of education for morale development includes a great variety of educational activities. The problems of communication tend to be common in large business organizations. There are a number of techniques and media for solving them. One is the letter from the president or some other member of the top management team. It is usually a brief, concise, single-page statement of the company's top leadership, concerning some current problem. It should be a problem of current importance to the company and the employee. It should be couched in good nontechnical English that the employee can understand. Such a letter gives the employee a feeling of significance. It has advantages of speed and low cost. It can meet the rules for good communications that were noted above. Another means of communication is the employees' annual report. An example of financial information for employees is shown in Fig. 27.2. The intent usually is to show the dependence of the employees' interests on the accomplishment of the company's primary service objective. Such statements therefore usually show the proportion of the customer's dollar that is spent for wages, in comparison with other expenses of the business. They may show the dollars of capital investment

[5] National Association of Manufacturers, *op. cit.*, p. 19.

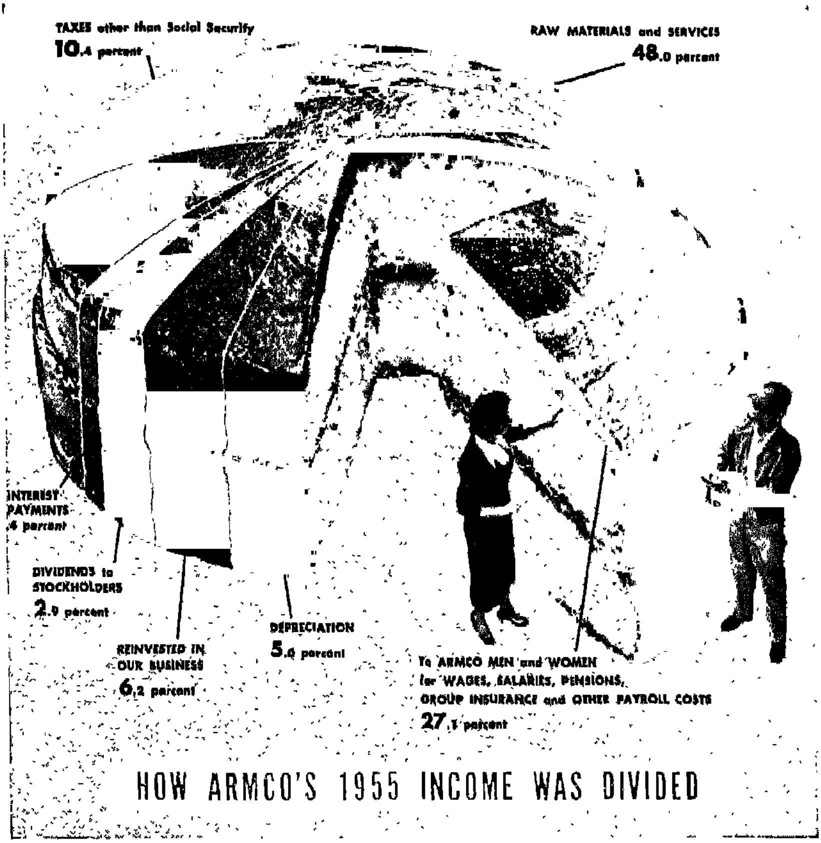


Fig. 27.2. A Graphic Financial Statement for Employees.
(Courtesy, The Armco Steel Co.)

that is required to make one job for one employee. The statement for the employees is usually identical with the stockholders' report, except for some simplification of accounting terminology and technique. The modern stockholders' report carries much information concerning the operations of the particular business, of course. The plant paper or magazine frequently carries interesting articles by plant executives. These articles are usually descriptive of what is done, how it is done, and why. An interesting development, in this connection, is the use of the self-administered knowledge test in the plant magazine. Most people enjoy taking them. They may learn quite a bit about their company in so doing. An example of such a test is shown in Fig. 27.3. Many concerns have used films to acquaint the employees with the product, processes, and conditions of the business. The use of our line supervisors as channels of communications

Enkabaiters

See If You Can Hatch Up The Answers

When you completed six months' service as an employee of American Enka Corporation, you were given, entirely at the expense of the Company, a hospital and surgical insurance policy with the Provident Life and Accident Insurance Company. Also, you were given an opportunity to cover your dependents at low cost under the same policy.

How well do you know the benefits of that policy?

1. If you or your insured dependents are hospitalized, you are entitled to hospital services for
   ——— a. As long as you require them.
   ——— b. 70 days of hospital care for each disability.
   ——— c. 30 days of care for each continuous period of confinement.
2. Your room and board benefits under the policy are
   ——— a. $6 per day.
   ——— b. $11 per day.
   ——— c. $4 per day.
3. Reimbursements for surgical expense incurred by you or your dependents
   ——— a. Always cover the entire cost of surgery.
   ——— b. Are made only for surgery performed in a hospital.
   ——— c. Are based on a set "Schedule of Surgical Benefits."
4. Coverage of extra services during hospital confinement
   ——— a. Is practically unlimited.
   ——— b. Is the same as actual cost, except for X-ray and radium treatments.
   ——— c. Is limited to $60.
5. In order to receive the benefits of your policy, you must notify the insurance company of your hospitalization or surgery
   ——— a. Within 20 days from the beginning of hospitalization or the date of surgery.
   ——— b. Within three months.
   ——— c. Within 10 days.

ANSWERS: 1. b; 2. a; 3. c; 4. c; 5. a.

30

Fig. 27.3. A Self-Administered Knowledge Test. (Courtesy, American Enka Corporation.)

implies that they have the facts, and have them first. Conferences with supervisors are often held by their line superiors, with the assistance of staff executives. The purpose is to give the facts to the supervisors, or to acquaint them with pending developments. There are many other kinds of educational activities for morale development.

The content matter of communications may be any factual information, including management's viewpoint, that will satisfy the employees' informational needs. It should be information that the employees want. Some idea of the needs can be obtained by the same means used in evaluating employee morale. We have noted previously such techniques as employee opinion polls, suggestion systems, exit interviews, supervisory morale reports, and others. Management statements are not in conflict with the Taft-Hartley Act, provided they do not include threats or inducements designed to weaken employee support of union proposals concerning matters in controversy.

The Company Periodical

The shop paper or company magazine has three important functions: it offers a channel of communication between the management and the employees; it assists in the development of the social life of the company; it aids in employee self-development. These functions require close coöperation with the other departments of the personnel division. The company periodical is primarily an educational activity. Its inclusion in the education department's work is suggested for this reason.

Its use as a channel of communication has been noted. The company periodical offers an opportunity for the company to present its point of view on matters that affect the employees' interests. The publication of open letters from employees may provide them with a means of making worth-while suggestions and criticisms of plant operations.

The shop paper prints interesting happenings in different shops or departments. It gives accounts of plant athletic activities. It carries interesting items regarding the older and better-known employees, and similar material. Such notes tend to fuse the employee into the life of the plant. The use of personal items can be carried beyond the point of diminishing returns, however. Some plant papers are made up almost entirely of "personals." These items can hardly be of great interest except to the employee and his immediate friends.

The company periodical can aid greatly in developing the employee's understanding of the relation of his job to the manufacture of the finished

product. Such a paper can publish articles on the product, its construction, and the processes involved in making its various parts. It can explain the methods of selling the product. Articles dealing with management and its relation to the worker tend to give him a better understanding of the subject, greater pride in his company, and a keener interest in his job. The usual result is better and more intelligent coöperation. This phase of the work was discussed in connection with education for morale development. It requires close coöperation with the labor relations department.

The plant periodical can assist the employee to develop himself either generally, or specifically for his job. For example, short courses of study on such subjects as shop mathematics, reading, etc. are sometimes run as special features. It can aid staff departments to get their ideas across to the employees. Thus the plant physician, the safety director, or other staff executives may have a regular column in the paper.

There has been a marked increase in the number of privately published company periodicals since World War II.[6] The trend has been toward a greater emphasis on articles dealing with company problems, policies, and methods. There has been less emphasis on "personals." There has been greater emphasis also on basic economics and the fundamentals underlying a free-enterprise economy. There is little tendency to preach, however. More effort has been made to evaluate reader interest, and to satisfy it. The company periodical has steadily become more professional in its character. This is probably due to the use of professionally trained editors, when a company can afford to employ them.

Plant Libraries

The plant libraries maintained by most large concerns have several important functions. They offer the employee further opportunities for self-development. The library may help to keep the various plant executives informed of interesting articles on developments in their particular fields. The librarian makes digests of new books and magazines. Notices of these articles are sent to the executives who may be interested. Bibliographies may be prepared for executives who are working on a particular problem. The library may be supervised by a trained librarian, for this reason.

The plant library sometimes is operated in coöperation with the city

[6] This development has been paralleled by the growth of the labor press. It was claimed in 1951 that there were over 800 labor publications, with a circulation of about 30 million readers. See Ray Vickers, "The Labor Press," in the *Wall Street Journal*, December 22, 1951. It is probable that the labor press is as big or bigger today.

library system. In some cases, a reading room is provided in connection with the plant library; it is open to the employees during the noon hour or other times when they are off duty. Some libraries lend books to employees. The engineering division or the research department may also have its own library, which is usually highly specialized and technical and may not be open to the employees generally.

The Training Process

Training is concerned with the development of the skill and knowledge in the employee that are required for specific jobs or it may seek to improve his effectiveness on his present job. It may develop him for a higher classification of work. The nature of the training methods and the extent to which they are developed are determined by the training needs of the particular plant. In some plants little training may be necessary for new employees; others, however, may find it necessary to train semiskilled workers for certain jobs. Technical developments may require the plant organization to train and maintain a supply of various skilled craftsmen.

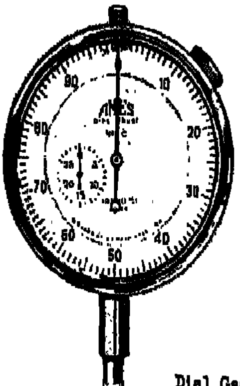
The work of training usually involves a close personal relation between trainer and trainee. It tends to break down into the following definite phases: preparation, explanation, demonstration, performance under direct supervision, performance under occasional supervision, and fixation.[7] The background of knowledge that is necessary for the performance of an operation is acquired, on the job from the supervisor, or more formally in the classroom. This is the preparation phase. Figure 27.4 shows pages from an instruction manual for inspectors. Such background is usually needed for an intelligent understanding of the instructor's explanation of what should be done, how it should be done, and why, in completing a specific training project. After this explanation, the instructor does one or more operations himself while the student watches. The instructor usually repeats his explanation during this demonstration. The student then does this work under direct supervision. The instructor watches him closely. He corrects any mistakes of the trainee then and there. He may require the student to go back to the beginning of the operation and start over again. The trainee repeats his instructions for each step in the operation, until he comes again to the one that he performed improperly. This assures that he will then perform it correctly. When the instructor

[7] The U.S. Office of Production Management used a four-step version of this breakdown during World War II. It was necessary for its Training-Within-Industry Section to teach millions of new supervisors how to train the influx of inexperienced operatives. The war effort probably would have been delayed seriously without the T.W.I. program.

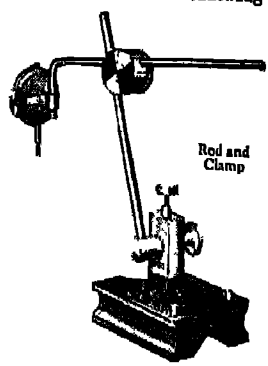
both the .250" and the .281" measurement before you proceed with checking the object or part.

This instrument has many uses but it is usually a problem for the workman to determine the value of the instrument and the proper method of its application.

Several types of instruments are illustrated on the following pages, each having a particular value.



Dial Gage



Rod and Clamp

-7-

Setting Adjustable Gear Gage

In order to check two gears, as shown in Figs. 8 and 9, with the adjustable gear gage, the following operations are necessary:

1. It is necessary to determine the center distance at which the gage pins must be set. The illustrations show the center distance of one gear as 3.318" and the other as 2.990". These dimensions, of course, are the distances between the centers of either gear and another of the same pitch diameter but opposite helix angle. When a component angle and a mating master gear of opposite helix angle are run together as shown in Fig. 10, the distance between centers is equal to half the sum of the center distances as given on the blueprint, or $\frac{3.318 + 2.990}{2} = 3.154$, the center distance.

2. The next step is that of finding the distance between the gage pins when their centers are 3.154" apart. The pins are each .125" in diameter. Subtracting one-half the sum of the pin diameters from the center distance gives: $3.154 - \frac{.125 + .125}{2} = 3.029"$, the distance between the gage pins.

3. The gage pins are then located and locked in position so that a combination of Hoke Blocks 3.029" long just pass between the pins with a snug fit.

Fig. 27.4. Pages from an Instruction Manual for Inspectors. (Courtesy, International Business Machines Corp.)

is satisfied that the student understands the method, he leaves him to do the work without supervision. He returns occasionally to make certain that the trainee has not unconsciously dropped back into old work habits. He gives any further assistance that may be required. This supervision becomes less and less frequent until the employee is able to handle the work without direct supervision, except in unusual situations. Instruction should be continued until an understanding of the method has become firmly fixed in the employee's mind. He should have acquired the necessary skill. In repetitive operations, the worker's motions are governed largely by motor reactions. This results in high speed coupled with great accuracy. It may be desirable, with such operations, to continue instruction until a definite work habit has been established.

Planning the Training Course

Special training courses may be needed when changes are made that affect the skill and knowledge of large numbers of employees. Such training needs may develop when the company is expanding or diversifying rapidly. These needs may develop also when new products or processes change substantially the skill and knowledge contents of important operations or classes of work. This work may be peculiar to the company or industry. The new course may be unlike other training courses elsewhere, in consequence. Its content must be determined by the requirements of the work. What are the objectives of the course? What are the criteria of proficiency? Into what phases does this type of work break down? What are the distinguishing characteristics of each phase? What is their significance in relation to effective performance? What should the learner know about them? What skills are required, and how can they be taught? In what order should they be taught? What tools, equipment, or other factors enter into the work? How can their effective use be taught? These and other questions must be answered before the content of the course can be determined. In general, the simplest and most fundamental phases of the work should be taught first, with gradual progress to the most complex and highly refined phases. The skill and knowledge which the learner acquires from each "block" or "unit" of work should serve as the foundation for the next step. It is evident from the above that to decide on the content of a training course requires a form of functional analysis. Its purpose is to obtain information that will enable the determination of the skill and knowledge required for proficiency in a given type of work.

Information concerning the training methods that are to be used must

be included in the plan. Each step in the training program should be planned to make effective use of the appropriate methods. The objectives of the program, and the level of skill and knowledge that should be developed, determine largely what is an appropriate method. Decisions concerning training methods cannot be made until we know something about the training problem. The methods for handling some of the more common problems will be discussed briefly. These include on-the-job training, vestibule training, apprentice training, and training for managerial jobs, when we go above this level.

On-the-Job Training

On-the-job training is difficult to define, because its nature appears to be obvious. Its objective is similar to that of any other training method, an increase in the knowledges and skills that an operative should have for an effective performance of his normal work assignments. Such training is usually given to the employee at his normal work place. The training materials are those jobs that would normally be assigned to him, with due regard for his current stage of development. The training equipment is usually the regular shop equipment. The training should be given by the employee's superior, or under the superior's personal cognizance. On-the-job training would include the instruction given to an operative by a supervisor before he undertakes a new work assignment. It includes the personal development that an employee obtains as a result of good direction and supervision from his superior. Such training may be used to upgrade the individual while he is at work on the job. This may be accomplished through the judicious assignment of more difficult projects within his job classification. It is evident that on-the-job training affects directly the command relationships, at the operative level, between superior and subordinate.

This method of training is relatively inexpensive. The foreman or supervisor may require training in the art of teaching. The steps in the training process should be understood. Instruction in motion-study principles is also given. These principles enable him to analyze the work requirements of the job more accurately. They help him to determine the causes of the workman's difficulties in acquiring satisfactory job proficiency. A knowledge of motion study enables the foremen to make suggestions for improving the job. To get the best results, the education department should assist the foreman in organizing his training work. It should check the progress of apprentices and trainees for key jobs.

Instruction by Training Supervisors

In some cases, skilled instructors devote their entire time to training employees on the job. They are under the jurisdiction of the training department. They may be assigned, however, to training in one department or in several. They are specialists in this work. The training of new employees is likely to be better organized and to be carried on more effectively, in consequence.

The Vestibule School

The vestibule school trains for a specific job or class of work. The apprentice school trains for a craft. It trains apprentices for the machinist's craft, for example. The vestibule school trains workmen to become lathe hands, milling-machine hands, etc. In addition, it may be used to give new employees a short course of training for semiskilled jobs. It has many of the instructional advantages of the apprentice school, such as organized work projects, training by a permanent staff of competent, skilled instructors, etc.

An important advantage of the vestibule school is the relatively short time needed for the training. The apprentice course may require several years for its completion. The vestibule school gives reasonable proficiency, in a few weeks or months, to new workers on semiskilled jobs or minor skilled jobs of a specialized nature. The learning period is likely to be the critical period that determines the worker's permanence. Vestibule training may have a beneficial effect on labor turnover. Furthermore, the training of new employees interferes less with the normal production of the shop. Finally, the vestibule school enables the creation of a semiskilled labor supply in a relatively short time when there is a shortage of this labor. Such schools were used extensively in industry, during World War II.

The Apprentice School

APPRENTICE TRAINING

Apprentice training is intended to give the learner sufficient skill and knowledge of a craft to enable him to do the work of that craft satisfactorily. The modern apprentice system differs from the guild apprentice system in at least two important aspects. First, personal instruction by a skilled master of the craft has disappeared. Some of the inspiration to

acquire craft skill has gone with it. In the second place, modern industry requires that journeymen be produced with greater speed and efficiency than was possible under the guilds.

There is today a potential or actual shortage of skilled craftsmen in many lines. Several factors account for this. Some craft unions restrict the relative number of apprentices that may be made. The intent is to restrict the supply of craft labor, to support a monopoly wage rate. It has been alleged that only the sons of members can become apprentices, in some cases. The intent is a monopoly of craft opportunity. Some employers do not object to such short-sighted policies. This is true, however, only as long as these employers can put their percentage of profit on top of increased costs, and the customer will pick up the check. Some employers avoid the expense of apprentice training by hiring journeymen who have been developed by other concerns. Most reputable manufacturers carry their fair share of the expense of apprentice training, nevertheless.

Trade associations have prepared and printed apprentice manuals. They have urged their members to train more apprentices. City trade schools and Y.M.C.A. schools have also undertaken craft training.

Many apprentice courses have been unsuccessful, for several reasons. Some concerns have not made the apprentice shop pay its way as much as possible by routing production work to it. Other concerns do not have a wage and promotion policy that will make the new journeymen want to remain with the company that trained them. The varying abilities of apprentices are not taken into account. The apt apprentice can progress no faster than those who are less apt. Many boys become discouraged because the period of apprenticeship and consequent low wages is unnecessarily long. They are likely to quit the course to take a production job at a higher rate of pay in another plant. Poor training methods detract from the effectiveness of the apprentice course. Such methods discourage apprentices from completing it. Finally, the methods of selecting apprentices are often unsatisfactory. No attempt may be made to determine the extent to which the candidate possesses certain innate capacities which are necessary for acquiring a high degree of skill in the craft.

While any extended discussion of modern industrial apprentice systems is not possible in this book, a few of their principal requirements can be pointed out. In the first place, the aims and content of the apprentice course should be definitely formulated and stated in an apprentice manual. The apprentice can then obtain exact knowledge of the nature of the work in which he must perfect himself. With such a manual, he can deter-

mine his progress for himself. This tends to keep active his interest in the course. Provision should be made for advancing him in the course as rapidly as his progress will permit. His rate of pay should be advanced as his proficiency increases. This provides an incentive to further effort. Eligibility for advancement should not depend entirely upon serving a specified length of time in each apprentice grade; job tests, oral examinations, and the ratings of instructors should also be taken into consideration.

The apprentice school should be under the jurisdiction of the education and training department. The school may be housed separately, in large companies, together with its own equipment, corps of instructors, etc. This arrangement offers many advantages. For example, apprentice training can be organized more highly, and graded exercise material can be used. Instructors who are good teachers as well as good craftsmen can be secured. Journeymen can be trained more quickly. Small concerns may train their apprentices on the job, as described previously.

Education and Training for Professional Operatives

A professional operative is one whose work is in a field for which specialized, professional training is required. A major proportion of his time is spent in solving, personally, assigned problems within his field. He has no substantial responsibilities for the direction and supervision of others during this time. Otherwise he would probably be a technical staff executive.

The education and training of the professional operative involves the development of those mental skills and knowledges that are necessary for success in his profession. These should enable him to engage effectively in problem-solving thought, within the particular professional field, provided that he has the mental capacity. Much of the operative's work has to do with some phase of planning and organizing. It is specialized work that has been assigned to the technical staff department in which he is usually employed. The work of such a department is a staff phase of management. The professional operative is usually an exempt employee, under the Fair Labor Standards Act, for this reason.

Industry relies on technical institutes and the professional schools of universities to give the basic training that the professional operative requires. The personnel representatives of large corporations visit these schools regularly. They hire many thousands of graduates annually. Many of these corporations run their own company schools. Such a school may offer cultural and professional courses. Such work is given usually

Fig. 27.5. A Sales Training Class. (Courtesy, Remington-Rand.)

by a division that is separate from the trade school divisions that operate apprentice and vestibule courses. Many of the employees are high school graduates who have been unable to get a college education. Company professional courses provide an opportunity for professional education that may permit these employees to advance into a professional field. Some companies pay all or part of the tuition of any employee who finishes satisfactorily a correspondence or university extension course. Any professional operative gets on-the-job training under the direction and supervision of his supervisor. His development may be followed closely by the personnel department. He may be given a planned series of transfers and promotions, if he shows promise. These changes will take him through other technical jobs in his department, or other departments. Other methods may be used to develop him in his field.

A good example of professional operative training is sales training for the distribution of durable consumers' or producers' goods. A sales training class is shown in Fig. 27.5. The training and education department may offer numerous training courses for the sales division. These courses are developed by the education department in coöperation with the division. They are offered with the division's approval. The instructors are usually members of the sales division. Courses may be provided similarly for professional operatives of the accounting department, the purchasing department, or any other staff department that needs and wants such educational service.

There have been critical shortages of certain types of professional opera-

tives for some years. It is probable that these shortages will persist for some time. The supply of professional operatives has been most critical in the physical sciences.[8] There are many reasons for this situation. The professional operative is usually a man of superior ability. He is a candidate for advancement to a managerial position, accordingly. The supply of technical operatives to fill minor executive positions frequently is depleted. The offsetting difficulty is the narrowness of a strictly technical education. It may be necessary to broaden such operatives before they can be advanced to executive jobs. Our failures to plan technical job assignments properly also may account for part of our shortages. Failure to separate the nontechnical and semitechnical phases from the technical phases of a job may occur. A professionally rated job, for example, may require the employee to spend only 10 percent of his time on purely technical work. Theoretically, 10 percent of our apparent requirements for technical operatives would be needed if this were typical of all professionally rated operative jobs. There are some practical reasons why such a straight percentage relation will not hold actually. Some concerns have been able to conserve their technical labor supply by analyzing the functional contents of professionally rated jobs, nevertheless. There is some possibility of accelerating professional training, but not much; time is one of the requirements for mental development. The absorption of large numbers of engineers and physicists by military research and development is another reason for professional labor shortages. The most important reason, probably, is the rapid technological progress of industry generally. This affects the need for professionally trained people in the social as well as the physical sciences. This problem of professional labor shortages is one of vital concern to industry. The competitive effectiveness of an industrial concern cannot be maintained without an adequate supply of professional operatives and executives. A solution of the problem is necessary to maintain the military superiority of our industrial economy over Russian socialism.

Executive Development for Operative Management

Operative management is largely project management. It involves some short-range planning and organizing. It is concerned largely with the control of action for the execution of the plans of higher executives. A brilliant plan that is poorly executed can produce only mediocre results, if any. The operative executive accordingly makes an important contribu-

[8] At the time that this was written, the President of the United States had recently appointed a committee to study the critical shortage of trained engineers and physicists.

tion. He is closely in contact with factory operations. The lower executive levels exercise a face-to-face leadership of factory operatives. Supervisory executives can influence morale greatly.

There may be a number of levels of executive service within the general area of operative management. The bottom level includes supervisory management. The top level includes principal plant executives. The proportion of administrative management in the executive job content increases as we approach the plant manager's office. Administrative management is largely group management. It involves considerable long-range planning and organizing. The proportion of such management in the plant manager's job usually is greater with single-plant than with multiplant operations. This is clearly in the area of administrative management above the plant manager's level in a corporation that operates a number of plants.

The specific executive development for an operative executive depends on the service level of his job. The job of a line department foreman may be similar to that of a staff department head from a leadership standpoint. The operative functions that they direct and the facilities for which they are responsible may be quite different, however. The problems of any line or staff department head are related to but different from those of the plant manager and other major operative executives. A development program for operative executives should deal with the problems of their present job. It should enable them to perform their present duties more effectively. Managerial effectiveness depends also on ability to coöperate intelligently with one's superiors. The program therefore should contain some information concerning the problems of higher executives.

Executive Cadet Training

Many companies operate training courses for recent college graduates or young noncollege employees of exceptional promise. The intent is to give the participants an initial training that will provide a basis for their executive self-development. The company gets some promising additions to its inventory of potential executives. Such courses have two principal phases: an organized work experience that will supply some practical background for future assignments, and an educational experience that will give them some managerial background. The two phases run concurrently. The first phase provides a broad experience with the operative work of the organization. The participants are transferred through a planned series of key departments. They usually are given operative as-

signments in each department. These assignments should enable the participant to come into contact with and observe the principal phases of the department's work. He starts usually in a line department that performs some primary process. He progresses through other line and staff departments until his planned work experience has been completed. The participant is going through the second phase at the same time. This phase consists frequently of two parts. The first is a series of basic management courses. These are given usually in the company school. The second part is a series of talks and discussions by departmental and divisional executives. These talks concern the objectives, policies, and methods of the department and division in which a participant is working at the moment. The progress of each participant is evaluated periodically. He may go into the inventory of potential executives if he still shows promise when he has completed the program. He has after that whatever further opportunities for development may be offered by the company. The extent to which any executive development program is developed depends on the size of the company, its rate of growth, and the point of view of its top management. The emphasis in any program is on self-development. The company merely provides an opportunity. There are no crown princes. The company underwrites no one's future.

Supervisory and Foremanship Training

Supervisory management is a phase of operative management. It is largely synonymous with departmental management. The ranks of supervisory executives therefore include everyone within the department who spends a major proportion of his time in directing and supervising the work of others. First-level supervisors, unit chiefs, branch chiefs, section heads, and department managers, both line and staff, are usually regarded as supervisory executives. It depends, to some extent, on the size of the department and the extent to which the executive gives a face-to-face leadership to the operatives under his command. A foreman is usually a department manager, except in some small concerns. The line foreman has a key position in the organization. Despite the various staff activities that have been developed, he is still the important connecting link between the higher executives and the operative force. The foreman frequently interprets the company's policy to individual employees. He is expected to interpret the worker's interests to the management. The foreman must adjust individual grievances satisfactorily whenever possible. He gives a face-to-face leadership to his men in his direction and

supervision of their work. He influences their attitudes. The foreman is therefore an important factor in the morale of the operative organization. The amount and quality of the work that his men turn out is in part a result of the training and supervision that he gives them. These are also a result of his skill in coördinating their activities. The effectiveness with which he discharges his executive responsibilities can reduce many of the indirect operating expenses of his department and greatly affect operating economy and effectiveness. Many foremen have been advanced to their present position because of such considerations as their long experience with the work of their department, their great skill in doing it, etc. However, craft ability and executive ability are not the same. The foreman's job is fundamentally one of executive leadership.

There are thousands of foreman-training courses in almost every major industry throughout the country. There are foremen's clubs in all industrial cities of any size. These clubs offer well-organized programs for foremen and supervisors. These clubs frequently are affiliated with the National Management Association, an organization of foremen's clubs. The membership of the local clubs includes the representatives of top management and middle management in local industries. The support that is given to such educational activities by higher executives shows the importance that is attached to the foreman's job.

A foreman-training course is any organized system of training that is designed to increase the effectiveness of supervisory executives. The content of the course may cover the adjustment of individual grievances, the technique of handling men, the principles of disciplinary action, the maintenance of quality, waste reduction, interdepartmental relationships, the control of production within the department, motion study and work analysis, and any other problem which may arise in the course of the foreman's daily work. The training course must be able to arouse the foreman's interest and to start him thinking about his job. This is easier to do when the participants are on the same executive level. Key operatives, group leaders, and assistant foremen may be grouped together in a separate course, for this reason. The content of the two courses may be quite similar.

A great many methods for training foremen and supervisors have been used. They include the lecture method, the study method based on the use of prepared material, and the conference method. A role-playing technique was used with the TWI Job Instructor Training Program during World War II. It has been used widely for training purposes since the War. Various training aids have been used such as films, flip charts,

and felt boards.[9] Industry relies heavily on the conference method for foreman training, however. The use of other methods is usually supplementary to it.

Some concerns give their supervisory trainees the equivalent of a work experience when they have completed their educational program satisfactorily. The manner in which they handle their trial assignment is evaluated. Those who pass this pragmatic test of results are given permanent supervisory assignments, as soon as they become available. Those who do not pass it are placed on other operative jobs. Every effort is made usually to protect the unsuccessful trainee against loss of "face."[10]

The Conference Method of Training

The conference method has been used successfully in other fields of executive training, as well as in foreman training. It may be defined as a method of training that seeks to develop greater executive effectiveness in the members of a group through the joint analysis and discussion of problems in a particular executive field. The conference method assumes that the required knowledge is to be found largely in the combined experiences of the group. It calls for the pooling of ideas and experiences. To the extent that this assumption is correct, there is no necessity for text material that will supply a background of facts and principles. This method is based on the premise that the real problem is to enable the participant to use more effectively the background and experience that

[9] The Minnesota Mining and Manufacturing Company, for example, concluded that its foremen knew what should be done, but did not understand clearly how to do it. This conclusion was based on a survey of the foremen. The management drew up a list of eight "must do's" that seemed to cover the job of the first-line supervisor. These "must do's" were weighed in terms of percentages of an 8-hour day. They were: job instruction, 45%; work simplification, 11%; orientation of new employees, 8%; receiving instructions, 7%; work distribution, 6%; human relations, 5%; directing technical assistants, 5%; making necessary reports, 5%. (The list of functions and weightings would be different probably for another company.) Each general foreman was expected to go over the list with each of his supervisors, and to make clear the what, how, and why of each function. It developed quickly that the general foremen did not have the requisite interviewing skills. A training program for the development of these skills was designed for and given to the general foremen. It included conferences, audio-visual aids, and role playing. See "Training First-Line Production Management" in the December 1951 issue of *The Management Review*.

[10] The practice of the American Smelting and Refining Company is an example. A management committee selects the candidates personally. The trainees are given 30 two-hour weekly sessions. The trainee is then put in a department with which he is least familiar as an "acting" supervisor for one week. He is given an official introduction to his group. The trainee is then given a test job for his group. He is told what to do, but not how to do it. His work as a supervisor is evaluated by his immediate superior and the management committee. He gets a regular supervisory job if he handles his temporary assignment successfully. See "Five Steps to Leadership" in the April 15, 1953 issue of *Modern Industry*.

he has already. This is to be done by developing his ability to think effectively concerning his problems. The conference reproduces the total situation of a technical staff committee at the minor operative management level. By participating in discussions, the participant clarifies his ideas. He develops his ability to determine accurately the proper objectives in a given situation. He develops greater ability to decide what should be done to attain them, how, when, where, why, etc. He has to apply the principles of logical reasoning to the solution of his problems. The conference method aids the participant in developing a greater ability to think effectively.

The place to plan most organizational developments is at the top. A subordinate's attitude is greatly influenced, in most cases, by that of his superior. Moreover, the size of the budget appropriation that can be obtained for this work depends on the interest and understanding of administrative management. A top-level conference to plan the course should be held first. The head of the manufacturing division and his chief subordinates may meet to determine the objectives of the plan, how it should be set up, what problems need emphasis, etc. Similar conferences are then held at lower executive levels to get the reactions of superintendents and general foremen to the plan. This direct participation in the development of the course usually creates an interest in it on the part of these executives. Finally the project is explained to the departmental executive. An effort is made to gain their understanding, acceptance, and support.

The conference leader is important in the success of this method. The participants are expected to think through their problems with a minimum of guidance. The leader must be able to stimulate discussion. He must not dominate it. Nor is it his function to supply the answers. He must have a good logical mind, because he is expected to summarize the results of the session. He should have a good appearance and personality, and keen intelligence. The leader should be able to command the respect of the participants, even though he may have little practical experience in their particular field. In large concerns where several conference courses may be in progress simultaneously, the conference leaders usually receive special training in advance.

There cannot be a discussion here of the many other principles and considerations that should be taken into account when the conference method is used. However, this brief discussion should be sufficient to make clear the nature of this method, and the reason for its importance in executive development.

Training for Staff Operative Executives

The methods for developing staff operative executives are basically the same as those used for operative executives generally. The principal objective of a program for such executives is greater proficiency in the particular field of specialization. The content matter of the program is determined by the knowledge and skill requirements of the particular field. The conference method may be used. It may be supplemented by the use of cases dealing with problems in the particular field.

The principal differences are found in the agencies that may be used for the education and training of operative executives. The company school may offer courses that deal with important staff areas. Many staff executives are members of the particular professional societies that are important in their field of specialization. The procurement and supply officers, for example, may be members of the National Association of Purchasing Agents. Accounting executives may be members of the National Association of Cost Accountants. The office manager is probably a member of the National Office Managers Association. These associations have local chapters, the meetings of which are educational, of course. The associations usually develop and sponsor, in addition, various educational programs for their members. Many companies pay part or all of the dues and tuitions of a staff executive who will join the professional societies in his field. There are other important agencies. The company may send some of its staff executives to the "orientation" courses of the American Management Association. It may make use of university extension courses. The responsibility for the executive's development rests on himself, regardless of the agency and method that is used.

The Understudy Method

An important purpose is to develop flexibility and stability in the executive organization. There should be one or more individuals who have been trained to take over each executive position when it becomes vacant. An executive may be away for some time because of vacations, business trips, illness, or for other reasons. His work may be handled by an understudy until his return. The executive is expected to train the understudy so that he can do the work satisfactorily. To assure that this is done, some concerns will not promote an executive to a position of greater responsibility until he has trained someone to take his place. For the best results, the understudy system should be a part of an organized promotion system. The executive should coöperate with the education department

in planning the understudy's development. We may have understudies for important administrative as well as operative executives. The understudy may be the second-in-command of the particular organization.

A classic variant of the understudy system is the Gilbreth three-position plan of promotion. Each employee in the organization is considered to be holding three positions. The first is the job from which he has been promoted, and for which he is expected to train his successor. The second is the job on which he is employed at present. The third is the job to which he expects to be promoted. He is expected to make every effort to train himself so that he can step into the higher job when the opportunity offers.

Other Methods for Developing Executives

There are other methods for developing operative executives. Some of them are helpful in developing the potentialities of these executives for general administrative responsibilities. These methods make such a contribution when they develop a company-wide understanding of management problems. Some companies use a "team" approach to the solution of interdepartmental difficulties. The team usually is composed of qualified experts from the departments that are affected. The team must have a leader, of course. He should be appointed officially by the higher line executive who has common responsibilities for the departments involved. These teams visit other companies that sometimes have a similar problem when the problem is new to our company. The team obviously is not a committee. Many companies use committee service, however, to broaden junior executives. The McCormick Plan of "junior boards" is a development of this idea.[11] Other companies use job rotation, a system of planned transfers of an executive between his present job and other jobs to which it is related. The intent may be to give the executive a better understanding of the requirements of other executives on these related jobs or it may be to break down the antipathy between line and staff personnel. It broadens the executive's viewpoint in any event. An executive may be given a special staff assignment that requires initiative, tact, judgment, and ability to work with others. These and similar methods begin to get us into the area of executive development for administrative management.

Executive Development Programs

The term "executive" includes all managerial employees who have substantial responsibilities for the direction and supervision of others. All

[11] The plan as originally stated will be found in Charles P. McCormick, *Multiple Management*, Harper & Brothers, 1938.

such employees from the lowest supervisory executive to the president are on the "management team." The term "executive development program," however, has come to have a special meaning. It refers to programs for the self-development of promising candidates for general executive responsibilities. The participants in such programs are usually major operative executives who show promise, or minor administrative executives who still lack knowledge and experience in the field of administrative management. One frequently finds the presidents of small companies in university programs.

The objectives of the program are certain values that both the participant and the company get out of it. The more important objectives are:

1. A broader understanding of business problems
2. A realization of the importance of a long-range policy and an organizational approach to the solution of such problems
3. Increased ability to think effectively in the development of sound solutions for administrative problems
4. The development of a "team" concept of the business organization
5. A supply of potential general executives

Most major operative executives have worked their way up through some line or staff division of the business. They tend to think in terms of the problems and conditions with which they are familiar. Their thinking is frequently provincial, in consequence. Their approach to problems tends to be a project approach. The operative executive is concerned with the daily difficulties in completing the day's job. He tends to have a project point of view, whether he is an operative executive in the sales, production, accounting, engineering, or some other division. The general executive is or should be engaged largely in long-range planning and organizing. He must determine the ultimate objectives of the company. He is concerned with the growth and development of the business toward these objectives. It is evident that the general executive must use an organizational approach to the problems of the business as a whole, and its principal divisions. The organization and its divisions must operate as a team, if it is to defeat its competition. Otherwise it will be defeated.

The quality of the thinking that determines the objectives and policies of the organization conditions largely its success. The intelligence of program participants usually is not a problem. They are highly selected men who have already a substantial record of success. The program can enable the participant to improve his capacity for effective thinking, nevertheless, by placing him in problem-solving situations in competition

with minds that are equally keen. There is a logic of effective thinking, of course, that can be studied. An increased supply of potential general executives results necessarily from an accomplishment of the above objectives.

A program in the field of administrative management is not intended to develop the participant's proficiency in the performance of his present duties. It may make the executive more effective in his present job, nevertheless. He should finish the program with a greater appreciation of the importance of coöperation. He should have greater ability to analyze problems. He should be more capable of an intelligent exercise of initiative. The executive should be able to give his superior more effective support, because of a better understanding of administrative management.

The content of an executive development program consists of some series of conference discussions or seminars that will aid the participant in accomplishing the above objectives. Figure 27.6 shows an executive development conference in session. The subject matter covered in the different conferences may deal with problems in the fields of managerial economics, general administrative management, managerial accounting, marketing management, manufacturing management, financial management, personnel management and labor relations, or government and industry. The program may include any subject that is considered by top management to be important for general executive development. It should be developed from the standpoint of administrative management, however.

The methods used may be any technique that will develop a broad understanding of administrative management, and improve the participant's ability to engage in problem-solving thought. A common technique is the case method. A business case is usually an integrated statement of a complex situation involving various difficulties of varying importance. These difficulties affect usually a number of departments and divisions of a particular business. The student must determine the principal limiting factors in the problem. He must draw conclusions concerning the objectives that are affected. The student must go through other steps in the solution of a problem that have been noted previously. No final decision may be reached, but proposed solutions are discussed by the conference. The specific method of using cases varies with the instructor who uses them. The "incident method" has attracted considerable attention recently. It uses a particular incident or problem situation as a "springboard" into the discussion of some general problem. The conference leader will answer questions of fact but not of opinion. The participants must draw out the facts by questioning. The conference discusses solutions on the basis of the

facts as developed. The incident methods simulates the situation of an executive who is interviewing a subordinate concerning a particular problem that has developed. Various teaching aids may be employed during the conferences, with any method.

A company may use its own company school, and in addition certain outside facilities for executive development. Many of our larger universities offer executive development programs for the business and industry. The university programs may be broader than the company programs, but basically they are quite similar. Large corporations use one or more university programs chiefly to prevent inbreeding and the self-indoctrination of the organization with its own ideas. The latter development can be fatal in a highly competitive economy. Many companies also use the general management seminars of the American Management Association. Thousands of American executives have participated in

Fig. 27.6. An Executive Development Program Conference. (Courtesy, The General Motors Institute.)

these seminars. The Society for Advancement of Management has been developing programs to aid middle management personnel in self-development for higher executive responsibilities. This society has chapters in all principal cities. There appears to be a general order in which executive development programs are offered to general executive candidates. The company program often comes first. The more promising candidates may be sent next to selected university programs. Some companies have developed policy programs. These programs discuss the same management fundamentals, but they apply them to recent or current top management problems with which the company is confronted. The participants are candidates who have passed successfully through the previous programs. The programs of management societies apparently may be fitted into the development picture at any stage.

The policies governing the conduct of executive development programs are much the same as those governing programs for operative executives. The emphasis is on self-development. Management prevents advancement on the basis of nepotism, favoritism, and political preferment as much as possible. It confines participation in executive development programs to executives who are on the same or contiguous service levels. Much of the benefit of such programs comes from a mutual sharing of experiences. The content matter of the programs should be enough above the participants' present level of thinking to give an executive an opportunity for further self-development. These programs should be supported, for greatest effectiveness, by executive inventory control, executive evaluation, and executive progress control. There are other policies. They rest on the principles that have been discussed previously.

The rapid and extensive development of programs for executive development at every executive level of the organization indicates the importance that American management has attached to them. Such developments are a reflection of the rapid growth and development of our economy. They come immediately from the corresponding growth of successful companies. They are in part a reflection of technological progress, and the rapidly changing demands that it makes on personnel at all levels. These programs reflect also the difficulties in retaining the loyalties and support of operative employees, with the rapid growth of labor unions. Such programs are a response to the growing complexities of the modern industrial organization. It is expected, of course, that these and related developments will continue. Executive development programs are a recognition of the importance of superior executive leadership in a dynamic industrial economy.

PROBLEMS

1. The management of a gadget manufacturing company became interested in the problem of morale development and maintenance. The company's product had good customer acceptance, based on a reputation for good quality. The management of the production division was well known for the use of modern, economical production methods. Its costs were relatively low, and its rate of profit on sales was good accordingly. The competitive position of the company had been improving steadily during the past 5 years. The company had had a serious strike within the last year, however. It was this strike that had caused the concern of top executives about the state of morale in the factory organization. A firm of personnel consultants was employed to make a morale survey. This firm used a questionnaire that placed emphasis on employee job satisfaction. An analysis of the survey results showed little positive correlation between job satisfaction and employee productivity. The conclusion was suggested that there may be little direct relation between employee productivity and morale. The management decided to continue its investigation of the morale problem, before accepting the conclusion. It contacted the pen manufacturer, in Problem 1 of Chapter 25, for information concerning a similar study that this manufacturer had made. The subsequent investigation of the gadget manufacturer indicated that the major cause of the apparent lack of correlation beween employee productivity and morale was in the field of communications for morale development. The company's executive committee concurred in the findings. This committee recommended to the president that an educational program be undertaken for the purpose of developing a more direct relationship between productivity and morale. The executive vice-president then directed the personnel manager to develop a plan for the accomplishment of this objective. It was further directed that the plan be submitted to the executive committee for its concurrence, and to the executive vice-president for his approval, before being activated.
   (a) Is this or is this not an educational problem? Why?
   (b) What are the noneducational phases of the problem, if any?
   (c) You have been given a directive. Outline briefly the basis of the plan that you will present to the executive committee.
   (d) You must be prepared to defend your plan before the executive committee. Outline briefly your supporting arguments for each phase of your plan.
   (e) Do you think that it would or would not help to present alternative plans, merely indicating the one that appears to you to have the greatest probability of succeeding? Why?
2. When a new man is taken on in a certain department, the foreman gives him a brief explanation of the job, runs a few pieces on the machine to show how the particular operation is done, and turns over the job to him. The new man is expected to pick up the details of the work from the operatives beside him. He has little further contact with the foreman, except when he is criticized for low production or too much scrap. The personnel records show

a high turnover in this department among short-service men, apparently in most cases because of their inability to make satisfactory earnings on piecework.

(a) Criticize the foreman's training methods. If the situation were called to your attention as the personnel department's training supervisor, what courses of action would be open to you? If this situation were found in several departments, what action might be desirable?

3. The technical staff department heads, in a certain plant, issue technical orders to the line organization. These orders are issued in the name of the plant manager. He feels that some assumption of line authority by these executives has developed; that the factory foremen have tended to become assistants to these staff executives in consequence. The manager believes that certain authorized programs have not produced the desired results chiefly for this reason. These programs have been concerned with quality improvement, cost reduction, and increased turnover of work in process. The manager also feels strongly that there should be a decentralization of responsibility for operations, and complete single accountability of line executives for results, as far as practicable. He recognizes that there should be a corresponding delegation of authority to the foremen. He believes, however, that the foremen are not ready to assume the increased executive responsibilities. The plant manager has requested the personnel manager to design a training program that will aid the foremen in developing themselves for greater responsibilities.

(a) How would you proceed to determine what content matter should go into the program?

(b) What should be your relations with other staff executives in the plant manager's office in planning the training program; in giving the program?

(c) What should be your relations with line executives above the grade of foreman?

(d) What training techniques are available for use with this type of training problem? How will you determine which ones to use?

(e) How can we tell whether your training program has done any good for the organization, after we have executed it?

4. The company has been spending large sums of money for research, new product development, cost reduction, and marketing research. It expects to have an increased rate of growth in its sales. This will be partly a result of opening up new territories in which the company has not done business previously. Top executives fear that their expansion plans may be upset by a lack of major operative and minor administrative executives.

(a) What would be your general approach to a determination of how many executives of what kinds and grades probably will be needed 5 years from now? What practical value does such an estimate have, if any?

(b) What would you do with the information after you had obtained it, assuming that it has some value?

(c) What would be the basic differences, if any, between the programs

for the development of major operative executives and minor administrative executives; line and staff executives?

5. A small concern engaged in job order production found, after investigating programs utilized by large companies, that it had neither the talent nor the finances to set up its own executive development program. The president was of the opinion that such a program was not necessary, since the company had been doing well in the past. It had, in fact, increased its volume of business by 5% over the last 5-year period. The treasurer and sales manager, however, pointed out that several competitors had increased sales volume by 15% to 20% in the same time period, and that competition in the future could be met only by developing competent executive leadership at the major operative and administrative levels of management.
   (a) Compare the views of the president with those of the sales manager and the treasurer.
   (b) Does the size of the company make a difference in the need for executive development programs? How can such development be provided in the small concern.
6. The results of a recent survey, taken among 5000 employees of a textile manufacturing firm indicated that employees generally believed that (1) the firm realized from 20% to 25% profit after taxes, rather than the actual 5%, (2) top management was greatly overpaid, (3) wage levels were below those of competitors, (4) management could afford to pay at least 20% increase in wages, (5) "scientific management" was a term used as a front for developing the organization into an impersonal organization under the influence of a few stockholders interested only in dividends.
   (a) What are some causes that lead to erroneous opinions, such as those expressed above. What principles and practices might be employed to correct them?
   (b) What is probably the state of morale in this organization? What reasons support your conclusions?

CHAPTER 28 •

• Personnel Research, Standards, and Planning

Research and Standards

STANDARDS are necessary for planning, organizing, and controlling the work of the organization. They are quite as necessary for the effective use of human forces in business as for physical forces. A general classification of standards was set up in Chapter 3. Provision for personnel standards was made in it, for the above reason.

Important research has been carried on in the fields of industrial medicine and industrial psychiatry. The methods of sociometric analysis that have been used by some companies have been noted. The three principal personnel research techniques at present are methods for: (1) job analysis, (2) analysis of employee attitudes, and (3) psychometric analysis. The analysis of employee attitudes was discussed in Chapter 25. It was noted there that since good morale is one of the principal objectives of the personnel and industrial relations division, accurate information concerning employee attitudes and their causes is necessary for the intelligent formulation of morale-building plans. It was also pointed out that a general morale rating can be established for a concern, as well as for individual departments or divisions. The overall rating becomes a morale standard for the company, with which departmental ratings can be compared.

Job analysis, a form of functional analysis, is the process of investigating and analyzing the functions in a work assignment or group of assignments. The resulting facts aid in determining the relations between the conditions and requirements of the work and the individuals who must do it. They bring out their significance from an organizational standpoint.

Psychometric analysis is the process of investigating and analyzing, by means of psychological tests and measurements, the characteristics and requirements of functions and conditions as they determine the requisite human abilities. Discussion will be confined to these techniques, and to the following personnel standards that are derived from the data thus

collected: job specifications, standard job classifications, standard lines of promotion, wage and salary standards, and criteria for personnel selection. There are others, but space will not permit their consideration.

Job Analysis

A job is a general work assignment. It has its service objectives. They determine the functions and the requisite physical and human factors in their performance. It is these job attributes that distinctly differentiate it from other such assignments. An operative job assignment is the ultimate unit of responsibility in organization structure. As we said above, a job analysis is an investigation and analysis of a general work assignment and the conditions surrounding it, to determine its requirements from an organizational standpoint. It differs fundamentally in this respect from time and motion study, which is a technique for investigating and analyzing an operation in the completion of a project. A distinction has been made previously between a general work assignment, or "job," and a specific work assignment, or project. A good motion-and-time study analyst may be a poor job analyst, and vice versa.

Job analysis has been applied to both executive and operative work to get factual data for improvements in organization structure. It is used in organizational planning. Job specifications for general excutive positions may be based on information that was obtained by job analysis. Such specifications are used in long-range planning for company growth and expansion, general organizational planning, and the design of executive development programs. These and similar functions are frequently the staff responsibility of an executive for general administrative staff services. The top personnel executive may be concerned largely with labor relations problems. The top organizational planning group often makes job analyses of general administrative jobs. On the other hand, an extensive staff development in the small concern cannot be afforded. The personnel executive is concerned with jobs and their personnel requirements. He must procure and develop the personnel required to fill these jobs. He may be asked, in the small concern, to take on additional responsibilities that have to do with organizational planning, if he is competent to do so. The difficulty has been in the past that the personnel executive has frequently known too much about the details of personnel techniques, and too little about organization. The use of job analysis by the personnel department to procure information regarding the job and the worker for purposes of employment, promotion, transfer, and training will be discussed here.

Three methods have been used in making analyses of operative jobs. They are interview and observation of the worker on the job, interviews with his superiors, and questionnaires. Some combination of these methods may be used.

The general character of the work involved in each job should be noted. The nature of the demands that the job makes on the employee should be recorded. The information may be obtained by observing the employee at work, noting what he does and how he does it. For example, the analyst may find that the work is very fine, that it requires constant attention and causes considerable eyestrain. As a result of his observations and conversations with the employee, the analyst will amass a great deal of information regarding the job; this may be recorded on a job analysis work sheet like that in Fig. 28.1.

The accuracy of the information obtained from this study should be checked by an interview with the department head. The employee's idea of his job and his supervisor's idea of it are not always the same. The latter's opinion is not always correct. The employee, because of his closer contact with the job, may point out certain personnel elements in it that his superior has not appreciated. His superior, conversely, may point out certain angles that are not apparent to the employee because he is not looking at it from a managerial standpoint. One of the analyst's problems is to harmonize these different points of view and to determine the actual personnel requirements for the job. He must bear in mind that it is rarely possible to secure the ideal man for the job. The employment office usually has to be content with far less than the ideal. The analyst therefore must determine the minimum qualifications as well as the desirable ones.

Questionnaires are unsatisfactory in the shop for several reasons. The questionnaire is likely to be inelastic. It is difficult to design one that will draw out all the essential information concerning each job. The average employee or shop executive may not take the necessary time to make out a questionnaire correctly. To fill it out on the job means that production is held up. It may be made out incorrectly because the shop worker may have only a limited education. He may misinterpret various questions. The questionnaire is likely to be illegible because of grease and dirt. The questionnaire method is used successfully in connection with selling jobs, clerical jobs, and executive positions. It may be necessary, even here, to check the responses by personal interviews.

The information concerning each job may be grouped in two general classes:

JOB CLASSIFICATION ____________

Plant Title ______________________ Standard Title ______________

Factor	Reason for Classification	Code	Classification
1. Pre-Employment Training.	This job requires the mentality to learn to:		
2 Employment Training and Experience.	This job requires experience on this and related work of		
3 Mental Skill			
4 Manual Skill			
5 Responsibility for Material	Estimated Cost		
6 Responsibility for Tools and Equipment			
7. Responsibility for Operations			
8 Responsibility for Safety of Others			
9. Mental Effort			
10. Physical Effort			
11. Surroundings			
12. Hazard			

	Job Class Total
	Described By: Date
	Classified By:
	Approved By:

Fig. 28.1. Part of a Job Analysis Work Sheet for Job Classification Purposes

A. That which cocerns the work
   1. Name of the job
   2. Job symbol
   3. Departments which do this or similar work
   4. The nature of the work and the responsibilities involved
   5. Its relations to other jobs
   6. The conditions of work, such as shift hours, speed and accuracy required, posture, monotony, health or other hazards, wage payment methods, starting rates, etc.
   7. Importance of duties, as indicated by the relative distribution of the employee's time
   8. The difficulties that the employee must normally overcome in performing his duties
   9. The executive to whom the employee reports, or thinks he reports, for each duty
   10. Any other information that may be required by the objectives of the job analysis survey

B. That which concerns the worker
   1. Experience required
   2. Education required
   3. Physical requirements
   4. Language
   5. Personal characteristics, etc.

It may be necessary to collect this information for hundreds of jobs. Comparability is important, in consequence. To increase comparability when the analysis has been written up in its final form, the degrees in which the various general requirements may be present should be established. The method is illustrated by the code below for evaluating the degree of judgment required for a given job. Of course such codes must meet the conditions in a particular plant.

Judgment[1]

A Errors may cause loss of life.
B Errors may cause personal injury.
C Errors may cause money loss.
D Errors may cause confusion, interdepartmental.
E Errors may cause inconveniences, intradepartmental.
F None

The Job Specification

Some writers on personnel distinguish between a job analysis, a job description, and a job specification. The term "job analysis" usually refers, in this connection, to the information on the worksheet for a particular

[1] W. D. Scott, R. C. Clothier, S. B. Mathewson, and W. R. Spriegel, *Personnel Management*, The McGraw-Hill Book Co., 1941, p. 124.

employee's job. It will be found usually that there are a number of general work assignments in different departments or divisions that are functionally the same. These may have different job titles, nevertheless. It is desirable to reduce the number of different job titles to a minimum. This facilitates transfer, promotion, wage and salary administration, and other personnel functions. The general statement covering the functions, conditions, and requirements of these like jobs is what is usually called a job description. The job analysis information, in final form, is known as the job specification. It states the general man requirements of the job, also the general work requirements and the physical factors that condition performance. An example of a job specification is shown in Fig. 28.2. A job specification provides an accurate, concise statement of the skill, knowledge, experience, age, and other personnel requirements for a particular job. It should state the minimum as well as the desired degree in which the employee should have the requisite qualifications for the job. It should summarize the working conditions so that the applicant can be informed of them. By means of appropriate job symbols, it should show the lines of promotion to and from the job.

The job specification offers several advantages. It establishes a mutual understanding between the shop and the employment office regarding the requirements of the job. The specification improves efficiency in selecting applicants, in consequence. It aids in giving the applicant a satisfactory understanding of the job and its working conditions. In cases where the applicant has the necessary minimum training, but additional training is desirable, the specification helps the interviewer to determine what this should be. He can notify the training department accordingly. Job specifications give new interviewers, who are not particularly familiar with the plant or employment work, a fund of information. It helps them to reach a satisfactory degree of effectiveness in a minimum time. Finally, it assists in the work of promotion and transfer. In short, job specifications are of great assistance in putting employment work on a scientific basis.

The personnel department, in Fig. 22.1, has a research and standards section. The job analysts will probably be attached to it. Job specifications should not be adopted, of course, until they have been approved by the employment manager and the heads of the departments affected.

Job Evaluation and Classification

When the concept of functional similarity was discussed it was noted that functions may have a high degree of identity when they have the same service objectives. This is particularly true when the accomplish-

INSTALLER

Revised: May, 1956

A. GENERAL

1. Occupational Code: 6312 Labor Group Symbol: K
2. Position exists in all districts.

B. DESCRIPTION OF WORK

The duties consist of installing, removing wholly assembled equipment, reconcentration work, inside and outside wire work, together with the associated accounting work. Incident to these duties are those involved in making contact with the public on matters of service rates and policies and in selling additional service.

C. OCCUPATIONAL REQUIREMENTS

	Importance			
Ability to	Major	Moderate	Minor	Unimportant
Develop manual skill		x		
Acquire technical knowledge		x		
Analyze problems		x		
Plan work	x			
Exert muscular effort		x		
Work aloft		x		
Work out-of-doors		x		
Work alone	x			
Make contact with the public	x			
Perform clerical detail			x	

D. OCCUPATIONAL CHARACTERISTICS

1. Location: Subscriber's premises - inside, outside, aloft.
2. Time: Permanent, day, forty hours per week, occasional overtime.
3. Posture: All positions at different times.
4. Speed: Moderate - set by self.
5. Degree of automaticity: Varied.
6. Accuracy: Average
7. Health hazards: Exposure to weather, dust, heat;
8. Accident hazards: Car accidents, falls, cuts, particles in eye.
9. Disagreeable features: Dirt, awkward working positions.

E. PAY

1. Method: Weekly.
2. Rate:

   Schedule Starting Maximum Period

3. Time and one-half for overtime in most locations.

(Continued)

Fig. 28.2. Part of a Job Specification. (Courtesy, Ohio Bell Telephone Co.)

ment of these objectives creates similar problems that involve the same performance factors. Such functions usually require a like background, training, and experience from the people who perform them. Jobs may be found in different departments with practically identical personnel requirements. These may differ in operating details, of course. Some may differ only in the names applied to them. It is desirable that all like jobs be covered by the same job specifications.

Jobs should be classified after analysis and specification. These must be evaluated first to determine their "job worth." Every job should contribute some required values to the accomplishment of the organization's primary service objectives. "Job worth" is an expression of the relative importance of such job values. It is determined usually by some job rating procedure. Such a procedure is applied by a committee, usually, to each distinct job. The committee determines the relative importance of the job in terms of certain work factors that are common to all jobs. The major work factors are usually skill, effort, responsibility, and working conditions. Skill and effort may be mental or physical. Responsibility may involve obligations for people or material things. Working conditions can be disagreeable or hazardous.[2] These major factors can be broken down into minor work factors if desired. Job evaluation may be applied to executive jobs when operative jobs have been evaluated. It may be necessary to revise the initial job classification when job evaluation has been completed. It will probably be evident that some jobs are more important functionally than others. It will be necessary, accordingly, to develop labor grades or classes. These grades fall necessarily within the major and minor service levels. These levels develop with the growth and expansion of the organization. When the classification has been completed, a job number or symbol should be assigned to each distinct job. The work of job evaluation and classification is never completed, actually. A company must either move ahead or fall behind, in a competitive economy. Jobs are always changing in most concerns for this reason.

It is the responsibility of management to determine what work is required to serve properly the customer's needs and desires. It is management's responsibility to group duties into assignable jobs. It is its prerogative, therefore, to determine the relative functional worth of these jobs. The resulting assignment of operative jobs should be submitted to employee representatives for concurrence or objection. Trouble may be avoided by so doing. Functional job evaluation is the basis of monetary job evaluation. Base rates for operative are bargainable.

[2] C. W. Lytle, *Job Evaluation Methods*, 2d ed. 1954, p. 66.

Job classification simplifies the handling of labor requisitions, requests for promotion, quits, and transfers. Every labor requisition and job specification should bear the number or symbol of the particular job. Job classification facilitates formulation of a rational wage classification, promotion plans, changes in organization structure, and the solution of similar problems.

Wage and Salary Classification

Wage and salary classification depends on monetary job evaluation. The latter depends on functional job evaluation and classification. Monetary evaluation establishes the pay differentials between job classes. Its purpose is to provide a logical and equitable structure of base wage and salary rates that rests on verifiable facts. It is not unusual to find, before job evaluation, that the base rates for the same job vary widely in different departments of the company. The salaries of minor executives may be too high or too low as compared with those of major executives. There may be other problems, in addition to the difficulty that almost every employee believes that he should receive more money. The creation of a wage and salary structure is a problem of major importance. It usually requires months rather than weeks to develop and introduce a solution of it. Collective bargaining is required for the acceptance of the structure of operative base rates. Individual bargaining is necessary for the acceptance of executive base rates.

The initial steps in the problem involve the analysis of the organization's structure. It should indicate the general service levels, such as major administrative management, minor administrative management, major operative management, etc. The various jobs in the organization can be provisionally assigned to them. This classification is too broad to be satisfactory, except for initial classification purposes. Any of these levels may include too great a range of such job differentials as intelligence, knowledge, experience, etc. The subsequent steps of job analysis, job description, job specification, functional job evaluation, and job classification have been discussed previously. Data obtained from the payroll division, the personnel records, and conferences with executives enable the determination of the present median, starting, and maximum base rates for each job and service grade. These rates must increase in geometric progression.[3] This is necessary to maintain the incentive value of between-grade pay promotions. It should not be less than 10 percent

[3] The equation for this progression is $R=ab^n$, in which R is the base rate for the service grade, b is the coefficient of progression, n is the rank order of the service level, and a is the fundamental base rate.

usually, to stimulate self-development adequately. The base pay rates for the various service grades should fall in a straight line when plotted on semi-logarithmic cross-section paper. It is unlikely that the present rates will do so. A straight trend line may be run through them, however. It provides a criterion with which these rates can be compared. It furnishes a basis for the adjustment of overall rate changes for each service grade. The pay differential between the base rate and the maximum rate for a given job usually varies from 20 to 30 percent above base. Otherwise there may not be sufficient incentive to induce the employee to apply himself and improve on the job.

In the interests of both economy and fairness, the rates should be compared with those paid by other concerns in the community and the industry for similar jobs or grades of service. Such comparisons become more difficult the farther we go from the unskilled operative service level. For example, the job of production manager in a plant of 500 employees is not the same as it is in a plant of 5000. The general geometric nature of wage and salary relationships shown in Fig. 28.3 is based on a study made by J. O. Hopwood for the Philadelphia Electric Company.

Management may wish to determine individually the base rate for each job in a given service grade. One method that has been used is known as the "point system." To apply this system the work factors in each job should be evaluated and weighted. It is necessary to distinguish the minimum degree in which each factor should be present. For example, the various amounts of formal education that may be required may be none, grammar school, junior high, senior high, college, a professional degree. Each of these in turn may be broken down further on the basis of the number of years of work completed in it. A maximum and minimum number of points is assigned to each work factor, covering the degrees in which it can be present. The determination of the number of points to be assigned is a matter of executive judgment. It is a simple matter, then, to determine the proper number of points for each work factor in each job, as shown by its job analysis, in accordance with the degree in which it is required. The total number of points to be credited to the job is the sum of the points for all work factors. The monetary evaluation of the points is also simple. Let us assume that starting rates for the particular service classification range from $225.00 to $265.00 per month, or a range of $40.00. The job points for the least important and the most important job in this grade are 81 and 126 points, respectively, or a range of 45 points. The particular job under consideration has been credited with 110 points. Its starting rate should therefore be $250.78. The same general

method may be applied to the determination of maximum rates within a job classification. It should be clear that this method establishes an arithmetic progression for rates within a minor service level. It was pointed out above that there should be a geometric progression for rates between service levels. The point system gives a straight-line approximation of a segment of the curve in Fig. 28.3. It is accurate only for a small segment.

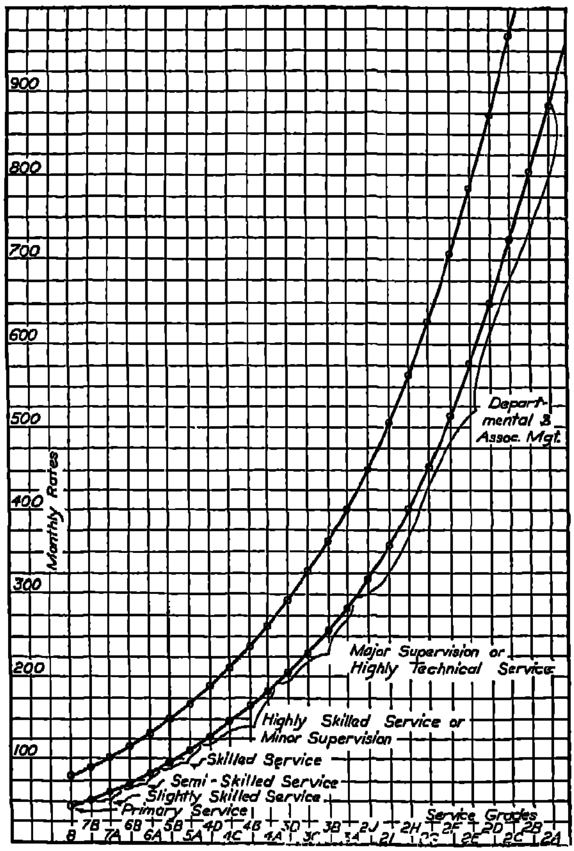


Fig. 28.3. Chart of Service Grades and Rate Changes. (Courtesy, J. O. Hopwood.)

That the determination of base rates is purely a mathematical process is not implied. There is no mathematical substitute for executive judgment. The extent to which some jobs may be blind-alley jobs must be taken into account, for example. However, such job evaluation methods give a quantitative, factual basis for judgment. Executives and operatives are

more likely to have confidence in the resulting standard rate classifications and ranges, in consequence.

Ratings and Rating Scales

A rating scale is a device for obtaining comparable measures of those qualities such as ambition, initiative, and personality, that are necessary for success in a given line of work but are too intangible to be measured objectively. These include such qualities as ambition, initiative, coöperativeness, and personality. In many kinds of work, such qualities may have an important bearing on the employee's value to the company. Scales for measuring them may be helpful in such personnel problems as promotions, transfers, rate adjustments, etc. Since these scales should be designed to fit a range of job personnel requirements in the company, their design requires job analysis. The personnel analyst should have also a knowledge of rating principles, and some experience in this field. The development of rating scales is the type of problem that may be given to the research and standards section in the personnel division.

In some plants, the department heads are asked to rate their employees on general ability. They may be given a crude rating scale which lists the qualities to be rated at the left of the scale. Check columns at the right are headed by such terms as excellent, good, fair, poor. The executive is expected to check the proper column opposite each quality. These terms are ambiguous. There may be great variation in the definition relative to a given personal attribute. The executive's opinion on the extent to which these qualities are present is likely to be inaccurate, in consequence. Furthermore, recent events may unduly color his judgment. He may rate unfairly an employee who has displeased him, giving previous good work less than its proper weight.

The selection of the qualities to be rated also is important. Characteristics that can be evaluated objectively should not be rated by a rating scale. For example, if reliable records of individual production are available, personal productivity should not be rated by a scale.

From the foregoing it is apparent that ratings may be extremely unreliable. However, there are rating procedures that correct for such weaknesses. A rating scale is shown in Fig. 28.4. The qualities to be rated are listed at the left on the rating sheet. The quality is not named on some rating sheets. It is defined, thus forcing the rater to read the definition. He is more likely to rate on the basis of the standard definition rather than on the basis of his own, which may be somewhat different. After the definition of each quality there may be a line. There may be descriptive

THE NATIONAL CASH REGISTER COMPANY
MERIT AND ABILITY EVALUATION
RATING FORM
(Office)

DEPARTMENT________________________

DATE
EMPLOYED__________________________

	CIRCLE THE APPROPRIATE NUMBER Refer to reference guide for complete instructions before rating									
	Low	Below Av.		Average				Above Av.		High
1 Accuracy of work	1	2	3	4	5	6	7	8	9	10
2. Use of working time	1	2	3	4	5	6	7	8	9	10
3. Ability to learn	1	2	3	4	5	6	7	8	9	10
4 Ability to work with others	1	2	3	4	5	6	7	8	9	10
5. Quantity of work	1	2	3	4	5	6	7	8	9	10
6. Initiative	1	2	3	4	5	6	7	8	9	10
7. Dependability and acceptance of responsibility	1	2	3	4	5	6	7	8	9	10
8. Conduct on the job	1	2	3	4	5	6	7	8	9	10
9. Punctuality and attendance	1	2	3	4	5	6	7	8	9	10
10. Orderliness	1	2	3	4	5	6	7	8	9	10

Comment:

Rated by________________________ Date________________________

A-1321-12 12-19-51 The NCR Co.

Fig. 28.4. A Personnel Rating Form. (Courtesy, National Cash Register Co.)

words or phrases at intervals under the line, on some forms. These phrases indicate different degrees of the quality. Such ambiguous terms as good, poor, etc., are not used. The rater checks the line at the point which in his opinion represents the degree in which the quality is present in the individual. Such a rating device is known as a graphic rating scale.

Quantitative values should not appear on the scale. They may influence the rating and cause what is known as a "numerical halo" effect. The rat-

ings may be evaluated by a clerk in the personnel office. All the lines opposite each quality are of equal length. The clerk lays on the line a strip of equal length which may be divided into ten equal parts. It may be numbered in sequence, 1 indicating the lowest degree, and 10 the highest. The clerk notes the space in which the check mark falls and enters that value for the quality. The total of the scores is a measure of the extent to which the particular qualities are present. Large concerns may use an electric scoring machine for this purpose.

There usually are differences in the strictness with which various executives rate the same employees. For example, a score of 75 or better for one rater may constitute an A rating. A score of 65 or better may be an A for another rater because he rates more strictly. Unless correction is made for these rating tendencies, different ratings by different executives for the same employee will not be exactly comparable. One simple method for this purpose is as follows. A large number of ratings by a certain executive are arranged in numerical order. The highest 10 percent are considered to be A, the next 20 percent B, the next 40 percent C, the next 20 percent D, and the lowest 10 percent E. When analyzed, this executive's ratings may show the following tendencies:

Numerical Scores	Rating
60—	A
50—59	B
38—49	C
28—37	D
—27	E

An employee whom this executive rates at 47 will be given a C rating. There are also other methods for correcting rating tendencies. It is necessary, furthermore, to minimize the possible halo effects of recent events and personal bias. The employee should be rated independently by more than one executive, in consequence. Each rater should of course be familiar with the employee and his work.

The executive should devote sufficient time to assure that each rating will represent his best judgment. This may be difficult if he is usually pressed with work. The executive should be informed regarding the nature, strengths, and weaknesses of the rating device. He should be sold on its use. In addition, he should receive some instruction in the use of the rating method.

There are other devices and methods for employee rating, in addition to the graphic rating scale. There are the man-to-man method, the point

system of rating, the forced-choice method, and others. Discussions of them will be found in advanced texts on personnel management.

Periodic merit ratings should be entered on the employee's service record. A given rating by a particular executive at a certain time may have little value in itself. Successive ratings by different executives over a period of time may build up a helpful picture of the employee's characteristics and abilities, nevertheless. Any objective evidence of the quantity and quality of results, or any other objective measures of his performance should be entered on his service record also.

Some companies reduce the time and cost of ratings, by confining them to key operatives and executives. This may be practicable with some classes of production operatives. It may be doubtful wisdom in the case of other operatives, however. It is usually required that each rater must talk over his ratings with each employee who reports to him. Much of the value of merit rating is found in this requirement. The employee knows where he stands. He knows what are regarded as his strengths and weaknesses. He gets personal help in self-development from his superior. The relationship strengthens the leadership position of this superior. A competent, intelligent application of a sound rating procedure tends to improve employee morale.

Promotion in Position

The general requirements of a promotion plan were discussed in connection with personnel procurement. It was pointed out that the formulation of lines of promotion is a requisite for any effective promotion plan. This is fundamentally a problem in functional similarities. A promotional relationship implies that the job from which promotion may be made and the higher job have certain basic similarities. It assumes that proficiency in the job at the higher service level requires chiefly a greater development of the attributes that are necessary at the lower level. Training for promotion has to do largely with the further development of these attributes. Education for promotion is concerned for the most part with providing the additional background, points of view, understanding of methods and relationships, etc. that are necessary to handle the broader responsibilities effectively.

The basic information necessary for the formulation of promotion plans is that developed by job analysis. After the various jobs have been analyzed and classified, they are assigned to the proper service levels. This requires the analysis of the job differentials, or work factors, that distinguish the various jobs from one another. After this has been done, each

job may be listed tentatively, with other jobs that appear to have a promotional relation to it. For instance, the job of machine shop foreman, which we shall call Job 110, might be related somewhat as follows:

Promote from Job 110 to	*Job under consideration*	*Promote to Job 110 from*
Job 112 Assistant superintendent of machine shop	Job 110 Foreman of machine shop	Job 25
		Job 37
		Job 51
Job 150 General foreman of machine shop		Job 75
		Job 86
Job 300 Inspection supervisor of machine shop		Job 101
		Job 109

There are other jobs to which promotion from Job 25 might lead. These are not shown because the above analysis applies particularly to Job 110. They would all be shown on a similar analysis for Job 25. If the promotional relationship with Job 110 is confirmed when Job 25 is analyzed, then the latter can be definitely listed.

The lines of promotion are sometimes shown graphically by means of promotion charts such as that in Fig. 28.5. Changes in service objectives, volume of business, policies, or major procedures may affect organization structure. This affects the promotional possibilities of different jobs. Furthermore, jobs themselves are never entirely static. For these reasons, a promotion chart may become obsolete in a relatively short time. It has the advantage, however, that it gives a complete picture of the promotional situation in the organization as a whole.

Tests for Selection

The selection of present employees or applicants for job opportunities was discussed in connection with the employment routine. The importance of proper selection was emphasized. It was noted that poor selection may cause great loss to the employer, as well as the employee.

Certain procedures have been used in American industry to assure satisfactory selection for job opportunities. The principal procedures are (1) the employment interview, (2) the weighted biographical inventory, and (3) selection tests. The employment interview was discussed in Chapter 23. The weighted biographical inventory method rests on the principle that certain facts in a candidate's previous record may have some value in predicting his probable success on a new job for which he is being

considered. These facts may concern such factors as previous work experiences, past earnings, educational background, age, participation in public and professional activities, and others. The relative significance of such factors can be established by the statistical technique of partial

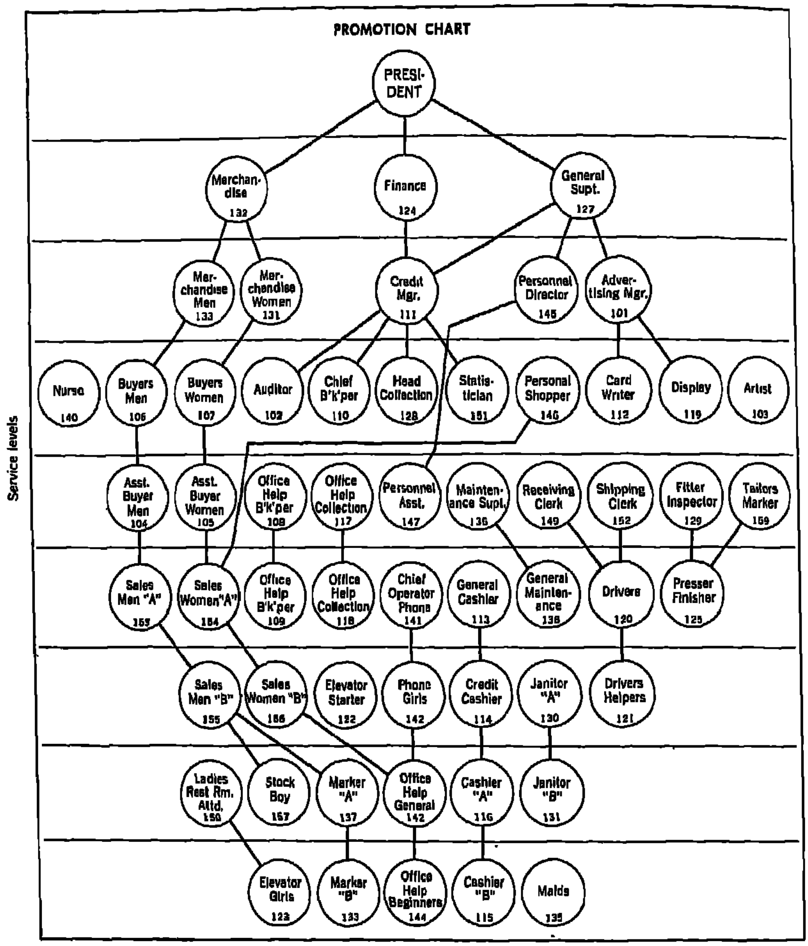


Fig. 28.5. A Promotion Chart

correlation. The facts are set up in the application blank or the employee's service record. These instruments were discussed also in Chapter 23. This discussion will be concerned chiefly with the development of selection tests by the personnel planning and research department, and their use by the empoyment department.

Selection tests are not a substitute for the methods noted above. They

can supplement them advantageously. They can add greatly to the accuracy of the selection process, when developed and administered properly. There are many kinds of tests. The principal ones can be classified as:

1. Psychological Tests
   a. Intelligence tests
   b. Personality tests
   c. Aptitude tests
   d. Vocational interest tests
2. Trade Tests

The distinction between psychological tests and trade tests is convenient, but of doubtful validity. Psychological tests are devices that measure certain mental attributes and capabilities for the purpose of predicting the candidate's success with a certain class or kind of work, given proper development. These usually test potential rather than actual capability. Trade tests are devices that measure the candidates' present development of the skills and knowledges required for a given job or class of work. They predict his probable success on the job on the basis of what he can probably do now. Both psychological and trade tests obviously are concerned with mental capabilities.

The different psychological tests can serve different objectives. Intelligence tests measure generally the individual's capacity to engage in problem-solving thought. These tests may indicate the speed and accuracy with which he can analyze and evaluate new situations. They give some measure of the ease and speed of learning. They are helpful in selecting candidates for jobs that involve planning. This is particularly true when we wish to determine the possibilities of advancement through the executive ranks. There are other factors in job success in addition to intelligence, of course.

The term personality indicates the nature of the response that one evokes from the people with whom one comes in contact. The reaction may be favorable, neutral, or unfavorable, and in varying degrees. This response may be in part an effect of the individual's attitude toward his associates, or people generally. It may be due to certain mannerisms or behavior characteristics. He may be quite unconscious of them. The persons with whom the individual comes in contact may find these mannerisms pleasant or unpleasant, nevertheless. The reactions of persons and groups to the individual governs his ability to coöperate effectively with them. It may govern also his ability to get effective coöperation and support from them. Personality tests attempt to determine the probable

behavior pattern of the particular individual on the job. These tests facilitate the evaluation of probable compatibility with his group.

Aptitude tests measure the potential ability of the candidate to perform a partciular job or class of work successfully. These do so by measuring the degrees in which the candidate possesses certain specific psychological attributes or elements. These are attributes that have been determined by research to be significant in the particular job or class of work. They may include such psychological elements as visual acuity, motor control, reaction time, accuracy of color perception, etc.

Vocational interest tests are used to determine occupational preference. An individual may have the actual or potential capabilities that are required for the particular work. He may not get the job satisfactions from the work that he desires. It is unlikely that he will have any great interest in the job, if he does not. The probabilities of success are less than they would be if he liked the work.

The work of planning the testing program, and the individual tests, should be done by someone with technical training in the field of applied psychology. A large company may have someone on its personnel research staff who is competent to do it. Otherwise, the company should get the advice of a consulting psychologist. The selection of the actual tests to be used depends on the nature of the job and the type of test that will give the best results. The industrial psychologist usually analyzes the job from the standpoint of its psychological elements before he attempts to design selection tests. He may decide that the applicant should have space perception, or the ability to distinguish between small quantities of time, or some other special capacity or a combination of several, if he is to handle the job with the greatest possible success. For another job, he may decide that he should have a certain level of general intelligence.

Various types of response may be called for by these tests. The subject may be required to respond orally to certain questions put by the examiner. He may respond in writing to questions that are printed on a standard form. A third method of response is performance. Here the subject is required to do certain operations. His performance is checked by the examiner. For example, in a picture test, certain important details are left out of each picture. The quickness with which the subject fills in the missing details is a measure, among other things, of his quickness of perception and his ability to correlate his experiences.

There are two kinds of response, free and restrained. In the first, the subject is permitted to answer in his own way certain questions that are put to him. The way he answers and the quality of his responses are the

basis of the examiner's judgment concerning the extent to which the capacity being tested is present. In the second, the way in which the response is to be made is indicated in the directions for taking the test. This method is generally used in written tests. This type of response is usually better when a large group is being tested. It may be better also when comparability is important and supervision is difficult. Two limits may be put on response, a time limit or a work limit. With the time limit test, a definite time is set when the test must be completed. The time limit set is one that even the most intelligent cannot meet, for otherwise the limit of the particular capacity under investigation could not be tested. With the work limit or "power" test, an attempt is made to determine the most difficult material that the subject can handle. There is no time limit. The time taken to complete the test and the quality of the response measure the extent to which the particular capacity is present.

There are still other problems after the important attributes have been determined. The conditions of work, for example, affect the individual's ability to work properly. Shall the total situation be reproduced approximately in setting up an aptitude test, or shall each special capacity be tested separately? In the first case, the applicant may be required to do certain operations that are psychologically similar to those which he would actually do on the job. For example, if the job to be filled involved visual inspection of small parts, the applicant might be required to sort out a number of similar objects in a pan and to work against a time limit. Inasmuch as the psychological elements in the sorting test and in the actual job are about the same, the number sorted in the time limit and the number of errors measure objectively the extent to which the necessary capacities are present. On the other hand, it may be desirable to test the requisite capacities separately. The results of these tests are later combined into a final score.

Statistical sampling methods are usually applied in these tests. All the psychological elements that may affect a man's performance on the job cannot be completely measured. An attempt is made to secure an objective measure for those which seem to be most important. It is impossible, furthermore, to give the tests to everyone engaged in a given occupation. A test must be given to a representative group, therefore, in order to determine its value. A fundamental principle of testing is that the tests themselves must be tested to determine their validity and reliability. These values must be determined, for a particular test, by actual trial with employees whose ability is known, and whose regular job is that for which the test is designed. The results of the proposed tests are correlated with

such criteria as ratings by superiors, production figures, volume of personal sales, or similar data. The criterion, of course, should be the thing that it is desired to predict. For example, if those who rank high on the test also rank high in production, then the test can probably be used successfully to predict the productivity of applicants for the job in question. The test is reliable if it will produce the same results when given to another group of representative employees. A maximum and a critical test score may be determined for the job. In connection with giving tests for general intelligence, it may be desirable to know, for example, the maximum intelligence that should be employed for the job. Any applicants who make a higher score than the maximum should not be employed for that job. They may become dissatisfied. The critical score is the lowest acceptable one; those who score below it should not be employed. They will probably prove unsatisfactory for this type of work.

The administration of tests presents some problems. Large corporations usually can afford the full-time services of a trained psychologist. Small companies cannot. They are limited in the amount of staff services that they can employ. They may be able to employ the services of a psychological consultant in planning a limited testing program. It is evident that selection tests may not be practical for the small company, unless they can be given by its personnel office, as a part of the normal routine of employment. This office can refer unusual cases occasionally to competent psychological counsel. Any tests that are used regularly must be simple. They must yield quantitative, unequivocal results that the personnel executive can be taught to interpret for normal cases.

Certain considerations should be borne in mind in giving psychological tests. The tests should be taken under standard conditions. The subject's attitude is important. The results of a test taken by a person who is highly nervous will not give a true measure of his capacity. The preliminary instructions are important. Good results cannot be obtained unless the subject is thoroughly familiar with the nature of the tests and the manner of taking them. Another factor in the success of these tests is an incentive to do them creditably. An applicant for a job has a natural incentive to do his best; he wants the job and will go through any reasonable procedure to get it. An interest in the tests and their development is often a sufficient incentive for employee test groups. There are other considerations that should be understood.

Trade tests are intended to indicate the applicant's present ability in a given craft or job. They do not show necessarily his ability to acquire greater skill or knowledge of it, or his potentialities for promotion. Inas-

much as they seek to determine a certain level of knowledge and skill, the items in these tests relate to the general subject of the occupation.

As in the case of psychological tests, the responses expected in the trade tests should be checked against the performance of employees whose ability is known. The applicants are then graded according to their test scores as novice, apprentice, journeyman, or expert.

It is evident from the foregoing that the formulation of both trade and psychological tests may require extensive investigations and analyses that cannot be handled by executives in the personnel division because in most instances they lack the time and special training that are required. The research and standards section in large personnel divisions may be responsible for these problems. Since the application of such tests affects the interests of both the line and the personnel executives, it may be desirable to integrate these interests through committee action.

The Personnel Audit

The soundness of the plant's personnel policy should be checked by a thorough annual audit of the company's personnel situation. It may be made by the research section or an outside agency. The personnel audit is a systematic and reasonably exhaustive analysis and statement of the objectives, policies, and practices in an organization that affect the relations between employees and management. The audit may serve a variety of purposes. It should provide a standard method of diagnosing a company's labor relations; this is desirable because the constantly changing conditions in industry make necessary a periodic check of their effects on labor relations. It provides a means of checking the effectiveness of the personnel department and its procedures. The facts developed by the audit tend to stimulate action and to supply the personnel executive with the basic information necessary for guiding this action. It assists him in formulating a long-range program based on fundamentally sound policies. It may make other contributions to the development of the company's labor policies and methods.

PROBLEMS

1. We have been having difficulty in selecting, training, and maintaining a force of operatives for a certain operative job. This job requires the employee to have certain specific capabilities. The plant manager has authorized the personnel manager to develop effective selection tests for this job.
   (a) How would you proceed to accomplish the assigned mission, assuming that you are the personnel manager?

(b) What general type or types of tests probably should be used in this case?
(c) How would you determine whether the tests were effective in selecting personnel for the job who can be trained and developed into capable operatives?

2. The company has an organizational planning group. It has been placed under an executive assistant to the president. This group has been making job analyses of the top divisional and headquarters positions in the company. The personnel director also reports directly to the president in this company. He has objected to the making of job analyses by the organizational planning group, on the grounds that job analysis is a personnel research function.
   (a) How would you decide this issue and why, assuming that you are the president?
   (b) What are the possible objectives of job analysis?
3. The company has decided to develop a job classification, as a basis for wage classification and administration.
   (a) How would this decision affect the design of the company's job specification form? Why?
4. One of the divisions of a large company has a merit-rating plan for its employees. The following are typical of the items in its rating device:

Characteristic Traits	Indicate Rating with Check Mark				
Attitude toward work	Enthusiastic	Interested	Average	Indifferent	Not Interested
Workmanship	Exceptional	Above Ave.	Good	Fair	Poor
Cooperation	Excellent	Willing	Average	Indifferent	Obstructive
Conduct	Exceptional	Above Ave.	Average	Below Ave.	Troublesome
(Other assumed traits)					

   (a) What type of rating device has been developed by this division?
   (b) In your opinion, does it violate any of the principles of sound merit rating? Make suggestions for its improvement.
5. What is a difficulty analysis? What is its relation, if any, to a job analysis? Should we or should we not regard it as a function of staff personnel management? What is the relation between a difficulty analysis and the method of limiting factors for the solution of problems?

CHAPTER 29 •

• Financial Management

The Finance Function

FINANCIAL management is the work of planning, organizing, and controlling the company's capital requirements, and the use of its financial resources. Finance is an organic function of any business organization. The cycle of production in a manufacturing concern involves the conversion of cash and credit into various production factors by its production division. The application of men and machines to materials produces goods or services that have certain use values. The latter values are sold by the company's marketing division to the customer for the satisfaction of his needs or desires. It is management's hope that payment of the company's invoice by the customer will reimburse it for all costs of producing and marketing the product, plus a profit. The principle phases of the financial function are therefore: (a) financial planning, (b) the procurement of capital, (c) the conservation of capital, (d) the disbursement of funds, (e) the origination of reports giving an account of the financial officer's stewardship, and (f) financial control.

The organization structure of the finance division depends on the kind of manufacturing in which the company is engaged. It depends also on the size of the company. It is affected by the viewpoint of top management concerning the mission that should be assigned to it. The head of the finance organization is a line executive, since he leads an organic division of the business. This organization operates, in Fig. 29.1, under the leadership of a vice-president and chief financial officer. This suggests that the company is a large one. This officer has undoubtedly complete responsibility, authority, and accountability for the financial functions, subject only to top administrative direction. The principal executives who report to him, in Fig. 29.1, are the treasurer, the comptroller, and the office manager. The latter is not a financial executive. He is often placed in the financial division of the company, however, for reasons that will be discussed in Chapter 30.

The chief financial officer is a general executive. He participates actively in the administrative management of the company. This executive must be a broad-gauge, practical "generalist" in all phases of the company's business. He must have, of course, a good administrative knowledge of his field. The chief financial executive is much more than a technical expert in accounting and finance.

Financial Planning

The problem of general administrative planning will be discussed briefly in Chapter 31. It will merely be noted here that financial planning is an important phase of such planning. The plans of the various line

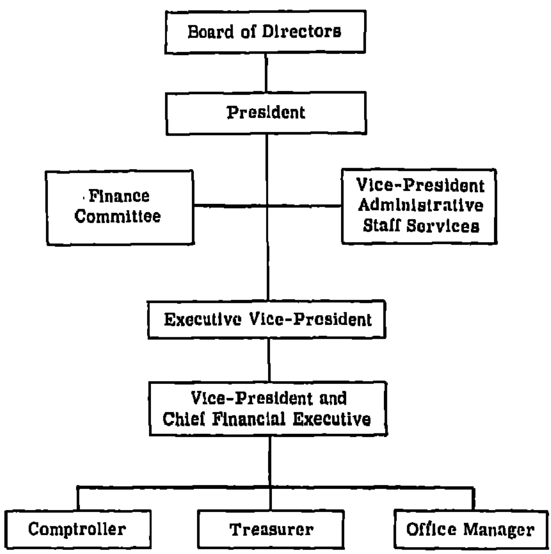


Fig. 29.1. A Financial Division of an Industrial Organization

and staff divisions require top management coördination and approval before they can be activated. These plans cannot be approved until it is known how we can finance the cost of executing them. The company's financial plans are the basis for arranging this financing. These are developed, accordingly, from the proposed plans of the various divisions.

The objective of a plan for financing operations is adequate amounts of funds. The adequacy of funds is determined by the financial requirements of divisional and company plans. The required funds must be available when and where they are needed. These considerations are determined by the programs and schedules for the execution of these plans. The

necessary funds must be obtained under conditions that will assure minimum costs for financing, as well as the continued financial health of the business. There are other requirements of satisfactory financing, both for long-term and short-term operations. The company's financial experts, or advisers, are familiar with them.

The details of financial planning depend on the nature of the business objectives that must be accomplished. These depend also on the characteristics and requirements of the company's financial problems. Such details must be left for texts in the fields of accounting and finance. We can comment only on the general method of approach to such planning. A distinction has been made previously between ultimate and immediate business objectives. The nature and requirements of long-range, intermediate, and short-range business planning have been discussed previously. Financial planning rests on such business planning for the company and its divisions. Long-range financial planning, for example, depends on long-range sales forecasting and business planning. The period covered in long-range business planning is usually 5 years or more. The period covered by plans for financing these operations obviously must be the same. The policies governing the use of rolling forecasts and overlapping plans must be the same.

Long-range business and financial planning are based on the secular trend of sales. A statistical extrapolation of secular trends may be merely an extension of the company's present relations with its competitors. Any plans based on such trends must be adjusted in the light of certain top management policy decisions concerning competitor relations. These decisions may have to do, for example, with the intention to increase the company's proportion of the market for certain products. These require the development of plans having to do with the diversification of product lines, new product development, the invasion of new market areas, the expansion of plant capacity, the decentralization of manufacturing operations, and many others. These plans usually cover a period of 5 years or more. These are drawn by various technical staff departments, and are subject to the concurrence of the line organizations that must execute them. These must have top management approval. These plans are usually reviewed annually, and revised as conditions change. Long-range plans for such developments are not detailed plans accordingly. These must be sufficiently definite, nevertheless, to enable the comptroller's office to estimate the capital requirements for such fixed assets as land, buildings, and equipment. It is the treasurer's responsibility to arrange for the provision of the needed capital. It is his duty to satisfy himself concerning

the accuracy of the comptroller's estimate of capital requirements. Any such estimates, as well as plans for financing approved developments, must go probably to the company's finance committee for concurrence and recommendation. Any plans and commitments for expenditures beyond a stipulated amount must have the approval of the board of directors.

The comptroller's office probably has ratios of current assets to sales and fixed assets to sales for a number of years in the past. It may have such ratios for the company, its principal competitors, and the general industry category in which it falls. The ratios should be extrapolated over the forecast period. These ratios may be changing for various reasons, such as the mechanization of processes. The comptroller's office has probably broken down the ratios for fixed assets into the percentage distributions by asset controlling accounts. It has accordingly, a basis for cross-checking the financial requirements of the company's expansion plans. Financial plans may be modified for other reasons. The company's long-range objectives may include an improvement in its profit performance, expressed as a percentage of total tangible assets. This depends on the rate of turnover of such assets, as well as the rate of profit on sales. Any such objective will condition the rate at which it is possible to build up total assets. The decision as to the means of financing business growth and expansion should rest initially with the treasurer. The general considerations underlying it will be noted when the treasurer's office is discussed. It is possible to correct errors in financial and other business decisions, to some degree, when plans are reviewed in subsequent planning periods. The company's plans for 1963, for example, would be long-range plans in 1958, intermediate plans in 1960, and short-range plans in 1962. These plans would be adjusted periodically, as 1963 approaches, to correct for business developments that could not be foreseen.

Intermediate plans are basically a modification of long-range plans to account for the effects of cyclical variation in business activity. These variations may affect the company's financial plans. The company may plan its needs for facilities or natural resources for 5 years or more in advance. It may buy scarce, diminishing resources on this basis, whenever they can be secured advantageously. It is not usual to commit funds or sign contracts for the purchase of facilities more than two or three years in advance of their required delivery. The cost is less if these facilities can be procured near the bottom of a business cycle. Capital turnover is faster than would otherwise be the case. We have a better opportunity to amortize the investment in these facilities out of depreciation and savings before

the cycle begins to ebb again. Break-even points tend to be lower. The reverse tends to be true, when the same facilities are purchased at the peak of a cycle. Many business executives have ignored these considerations, in recent years, for a number of reasons. It is difficult to determine a company's position in the business cycle at a given time. The secular trend of business has been sharply upward since World War II, with a few minor interruptions. This trend has been due partly to inflationary policies of both business and government. It has been due also to a very sound development—increasing *per capita* production, in physical units, resulting from research and development. Increasing birth rates have been another factor.

A feeling has developed, however, that again we have "new high levels of prosperity," and that they are permanent. Various surveys, in recent years, have reported the belief that "the government will not permit another depression." The useful life of most capital assets extends well beyond the time limits of most business cycles. The postdepression generation of executives reasons, nevertheless, that purchases of facilities should be made on the basis of the anticipated secular trend of the company's business, ignoring the present status of the current cycle. Those companies whose top managements have based their financial policies on such assumptions have been the more successful since World War II. They have improved their competitive positions. Their profit margins have increased. They have been the growth industries whose stockholders have made substantial capital gains. It is true, undoubtedly, that the strong upward trend of business and the country's economy will continue. It is true also that the government now has great powers for "planned inflation." It has not yet been proved that some combination of politicians, economists, and businessmen can control the business cycle, in a free economy. The business situation could deteriorate rapidly and extensively, if the assumption is not correct.

The foregoing are some of the considerations that must be taken into account by financial executives in developing and executing financial plans. This is particularly true when the commitments for large capital expenditures must be made. It is evident, however, that decisions based on such considerations affect the future of the entire organization. They affect decision-making in all major divisions. This is another reason why major plans and policies of the financial division must have the concurrence of the company's finance committee, and the approval of higher line authority.

Short-range business planning requires further adjustment of forecasts to account for the effects of seasonal variation in business volume. It involves also adjustments for unforeseen contingencies. Short-range financial planning is concerned, accordingly, with current financing. The treasurer should have the right of decision concerning the methods of current financing to be used. He is subject, of course, to general direction by the chief financial officer. Some of these methods will be noted briefly when we survey the treasurer's office. There are various techniques for financial analysis that are helpful in determining the amount of current and intermediate financing that will be required. These usually are applied by the comptroller's office. The results are available to the treasurer for purposes of financial planning and execution. Certain techniques for financial analysis will be discussed later.

The application of such techniques throws light on the probable profitability of the company under various proposed plans. These aid in determining the amount of capital that the company can be expected to generate internally, through its operations.[1] The difference between the funds required for a period and the funds that can be made available internally represents the amount of funds that must be secured from external sources.

Financial planning is done on the general administrative levels of the organization. Its importance is indicated accordingly. The immediate responsibility for such planning rests on the chief financial officer. He may be also the treasurer. Both the treasurer and the comptroller participate in financial planning. The required financial facts and analyses are supplied by the comptroller's office. Such plans must have the concurrence of the finance committee. This committee has a staff responsibility for coördinating the thinking of the principal divisional heads concerning the need for and use of funds. Major financial plans require the approval of the board of directors.

The Treasurer's Functions

The treasurer's office is established usually by the company's bylaws. The treasurer may be a member of the board of directors. He reports directly to a vice-president and chief financial officer, in Fig. 29.1. The principal functions of the treasurer's department may include (1) the receipt and custody of funds, (2) the disbursement of funds on proper authority, (3) the conservation of capital, (4) the origination of policy

[1] Capital generated is not the same as net income. It is (net income) plus (depreciation) plus (charges to other reserves) less (dividends).

governing the financial operations of the company, (5) corporate financing, both short-term and long-term.

The original functions of the treasurer were the receipt, custody, and disbursement of funds, on proper authority. Other duties have been added, over the years. The billing department of the company invoices the customer for goods and services delivered. The customer's check is forwarded, when received, to the treasurer's department. The receipt of the check is the basis of a credit to accounts receivable by the accounting department, and to the particular customer's account. It is, at the same time, the basis of a debit to cash. The treasurer is responsible for the safe custody of this cash. His office usually deposits it in a bank. The treasurer is responsible also for cash equivalents, such as any stocks or bonds that may be held in the treasury.

The cashier's section of the treasurer's department disburses funds on proper authority. The accounting department, for example, may receive a voucher, authorizing the payment of a supplier's invoice. It was noted during the discussion of purchasing procedure that this voucher may be originated by the purchasing department, when a partial or complete shipment of an order has been received from the vendor, and accepted. The accounting department credits accounts payable, and the particular vendor, with the amount of the invoice. It debits the proper materials controlling account, and the account for the particular material, with the amount that has been received. The voucher is forwarded to the treasurer's office for payment. It has previously been approved for payment by the purchasing department, and has been audited by the accounting department. The cashier's office can pay the invoice on the basis of such authorization. There are other ways in which the disbursement of funds can be authorized. Some evidences of authority are necessary. The company's books of account are usually audited annually by a firm of certified public accountants. The auditors of this firm will wish to establish the presence and availability of those funds for which the treasurer is accountable.

It follows that the treasurer has a responsibility for the conservation of capital, subject to planned and authorized expenditures. There is an obvious relation, for example, between a company's current financial liquidity and its ability to meet current bills promptly, without undue recourse to the banks for current financing. The treasurer watches the cash position closely. This is indicated commonly by the ratio of cash to current liabilities. He watches, of course, the company's current position, as indicated by the ratio of current assets to current liabilities. This and

other financial information is furnished by the comptroller's office. The treasurer does not determine the purposes for which available funds shall be expended. This decision is made by the president or the board of directors, on the recommendation of the appropriate committees. The treasurer has a right to question the propriety or necessity of proposed expenditures. This right grows out of his obligation to conserve the company's assets.

The treasurer has the right of decision concerning the execution of arrangements for financing the company's operations. It is presumed that his plans have had the prior approval of the chief financial officer, the concurrence of the finance committee, and the final approval of such higher authorities as may be necessary. The objectives, policies, programs, and methods of financing are set up in these plans. The treasurer's problem breaks down into two major phases: the short-term financing of current operations, and long-term financing. Current financing is concerned largely with capital provision for the execution of short-term business plans. It involves the arrangement of a line of credit with the company's bank. It requires the negotiation of short-term loans, within the limits of this credit line. The obligation to repay the loan may be acknowledged by the company's note. This note may be secured by a pledge of the company's accounts receivable, or some other security may be offered. Other means of short-term financing may be used. Some industrial companies have sold bonds, for example, with the stated intention of using part of the funds for working capital. This may be quite proper for a company that is growing rapidly. Net working capital is represented by the difference between current assets and current liabilities. This difference must increase with business growth, if a sound ratio of working capital to sales is to be maintained.

Most of the proceeds of bond sales are used for long-term financing, however. There are, of course, other methods of long-term financing. Such financing provides the funds for growth, expansion, and diversification. It results chiefly in addition to the company's fixed assets. The importance of long-term financing to growth industries is indicated, therefore, by the investment of funds in fixed assets. The U.S. Chamber of Commerce surveyed the postwar investments of industrial and public utility companies from 1945 to 1954.[2] The average investment per worker was $12,605.00. The distribution of investment was as follows:

[2] *Investment for Jobs,* U.S. Chamber of Commerce, Economic Research Department, Washington, 1954.

Asset	Percent of Total
Machinery and equipment	25.5
Buildings	25.0
Inventory	23.4
Working capital	22.8
Financing costs	1.8
Land	1.3
Miscellaneous	0.2
Total investment	100.0

The methods used by the company are determined, in part, by its financial condition. The current cost of capital is usually a consideration. There are other considerations that may be equally as important at different times, under different circumstances. The relative economy of alternative methods of getting the capital must be evaluated. The long-range effects of these methods on the company's operating economy should be taken into account. There are other considerations in long-range financing. It is usually the treasurer's responsibility to study the alternatives. He is expected to recommend a course of action that is best in the long-run interests of the company. It may be the treasurer's decision to increase the company's equity capital through the sale of common or preferred stock. He may elect to recommend long-term borrowing. This may be accomplished by the sale of bonds, as noted above. The company may sell a long-term note to an insurance company. This note may be secured by a mortgage on the properties for which the funds are needed. Railroad companies frequently finance the purchase of rolling stock by the sale of equipment trust certificates. There are other methods for securing funds from external sources. Discussion of them can be found in any good book on corporation finance. The treasurer can get the advice of experts in banks, investment houses, insurance companies, and other sources of funds. He will get the advice of the finance committee, of course. It is evident that decisions concerning the amount and nature of the financing that must be done can have far-reaching effects on all divisions of the business. Decisions that have strong interdivisional influences must go to a higher echelon for coördination and approval. The reasons were discussed in earlier chapters. They are the reasons why the treasurer has the initial right of decision, but not the final right.

Many of the above decisions are "policy decisions." They are based directly on the known requirements of previously determined objectives

and policies. They cannot be decided, obviously, until these objectives and polices have been determined. There are many financial questions that require a decision, in addition to those that have been noted previously. For example, what should be the ratio of net profits retained in the business to net profits disbursed to stockholders? The conservation of funds for growth purposes is only one consideration. What rate of amortization of capital equipment is sound for a company that must mechanize its operations to remain competitive? What should be the company's profit objective, before taxes, in terms of percentage of profit on net assets? Why? It is the "why" that leads to the determination of what is sound principle, underlying the particular policy. It is the responsibility of the treasurer to make the analyses, initial decisions, and recommendations concerning financial policy.

The treasurer is regarded here as a line executive. He has the immediate responsibility for capital provision. He is not regarded as a line officer by some authorities for the following reasons: the treasurer has a small organization. The devolution of the finance function does not lead directly and immediately to the creation or distribution of customer values. Responsibility for the use and conservation of assets is placed on the using agency. These authorities regard the financial function as a service function for production and distribution. On the other hand, every piece of equipment in a factory usually has an asset number assigned to it. The production division is accountable to top management, through the financial division, for the presence and condition of each asset item that is charged to it. The comptroller's department keeps the company's asset accounts, of course.

The Comptroller's Functions

The comptroller is the principal staff executive of the financial division. He reports directly to the chief financial executive in many concerns, as in Fig. 29.1. His functions have been completely separated from the finance function in other companies. He reports directly to the executive vice-president or the president in such cases. This is more likely to be true when the company has no executive for general administrative staff services, as in Fig. 6.1. The comptroller may perform more than the function of staff financial control in such case. There are a number of instances, in fact, where this top staff services group has grown out of the broadened activities of the comptroller's office. The general staff services executive is not necessarily an accountant, however.

The duties that are assigned to the comptroller's office depend on top

management's conception of the comptroller's mission. The Controllers Institute of America considers that it should include the following duties: (1) To establish, coördinate, and maintain, through authorized management, an integrated plan for the control of operations. (Such a plan would provide for cost standards, expense budgets, sales forecasts, profit planning, programs for capital investment and financing, and the necessary procedures for effectuating the plan.) (2) To measure performance against approved operating plans and standards, and to report and interpret the results of operations to all levels. (3) To measure and report on the validity of the objectives of the business and on the effectiveness of its policies, organization structure, and procedures in attaining those objectives. (4) To report to government agencies, as required, and to supervise all matters relating to taxes. (5) To interpret and report on the effect of external influences on the attainment of the objectives of the business. (This function includes the continuous appraisal of economic and social forces, and of governmental influences as they affect the operations of the business.) (6) To provide protection for the assets of the business. (This requires adequate internal control and auditing, and assurance of proper insurance coverage.)[3]

It is evident that the accountants have awarded much of the field of general administrative management to themselves. The above duties infringe, in some instances, on the assigned missions of other major divisions of the company. This may be one reason for the emergence of the top administrative staff services group. The responsibilities for some or all of the following functions may be delegated to the comptroller's office: (1) accounting, (2) auditing, (3) budgetary planning and control, (4) business statistics, and (5) financial analysis.[4] The details of accounting policy and procedure are the province of the professional accountant. Consideration can be given here only to the broader managerial aspects of the above functions.

The Accounting Functions

The accounting functions have to do primarily with the work of collecting and recording, in the company's books of account, the various

[3] *Careers in Management, Accounting and Control,* Controllers Institute of America, 1951, pp. 8, 9.

[4] The Controllers Institute believes that the following functions should be assigned; (1) general accounting, (2) plant accounting, (3) cost and statistics, (4) budgeting, (5) procedures for accounting and budgetary controls, (6) taxes, (7) office methods, (8) audit, (9) office service, in some cases. *Ibid.*, p. 14. It is considered also that the function of organization planning should be assigned to the comptroller's department. *Ibid.*, p. 10. (Professional accountants consider the term "controller" to be more descriptive of the mission under discussion, than is the term "comptroller.")

income items, expenses, and charges that are incurred in the operation of the business. These should be so recorded that their influence on the financial condition of the business and its profitability can be determined. Such accounting entries should supply the data that will enable the comptroller's office to determine the financial effectiveness of the organization and its subdivisions in the accomplishment of their objectives. There are many aspects of organizational effectiveness that cannot be expressed in monetary terms, of course. The principal functions of the accounting department are general accounting, factory accounting, accounting for the marketing functions, and cost accounting.

The general books of account summarize, in monetary terms, the results of business operations. These books are set up to correspond with a basic classification of accounts. This classification is composed of broad categories of income, expenses, assets, liabilities, and net worth. Some categories deal with general income accounts. These may be set up by territories, product lines, or some other significant basis that will facilitate analysis. Other categories include indirect expense accounts. Such expenses may be any departmental or general business expenses that cannot be charged directly against the product. There are categories of product accounts within which direct expenses can be summarized by product lines. There are broad classes of asset accounts. These may break down into general accounts for inventories, small tools, machinery and equipment, land and buildings. Each of the major categories may break down into a large number of controlling accounts, representing subcategories. These controlling accounts are summary accounts into which the totals in subsidiary ledgers are closed. The general accounting section originates various reports, as required, showing the changes in the totals of the controlling accounts. A comparison of these totals with those anticipated in the company's financial plans, and an analysis of the variances, often indicate where corrective action may be necessary. Controlling accounts should be set up in conformity with the delegations of responsibility and authority within the organization. These delegations should conform to the major groupings of company functions on which our organization structure is based. Maximum results usually cannot be obtained unless personal accountability for them is established.

Factory accounting deals specifically with the assets and expenditures required to operate the plant. The factory accounts represent a more detailed breakdown of the corresponding controlling accounts in the general books. The various departments of the factory, both line and staff, may have a standard classification of expense accounts. It plays an important

part in budgetary control. This classification usually distinguishes between those expenses that cannot be controlled by the department manager, and those that can. Controllable expenses include the indirect expense and labor that are required to operate the department. It includes the direct labor expense that is incurred within the department. Such labor expense is a credit to departmental payroll and a charge against a product order. Payroll accounting is an important part of factory accounting. The direct labor cost may be 70 percent or more of the prime cost of some products. It may be as low as 10 or 15 percent in others. It is necessary to make payroll deductions for income taxes, social security taxes, and other reasons, in any event. These deductions can be a source of labor relations problems. The payroll department may be located near the personnel department for this reason.

The work of accounting for the marketing functions rests on the same accounting principles as factory accounting. The accounting procedures are different, because of basic differences in the functions of production and marketing. The objective is accounting information that will enable the comptroller to determine distribution costs with reasonable accuracy. It includes information that will enable marketing executives to evaluate the economy with which the various elements of the marketing organization are operating. It should enable general executives to determine the effectiveness with which marketing executives accomplish approved plans, in so far as monetary criteria can show this.

Industrial Cost Accounting

One of the most valuable techniques available to management is industrial cost accounting. Its principal phases are: (1) the accounting phase, which includes the collection of information on manufacturing expenses and its allocation to operations, products, and organization units; and (2) the managerial phase. The latter includes the interpretation of accounting information for the purpose of evaluating the effectiveness of past performance, controlling current operations, and guiding future activities to the best advantage.

Cost accounting installations vary considerably between industrial concerns. The basic steps of cost procedure are quite similar, nevertheless. First, provision must be made for the collection of such manufacturing expense information as direct labor, direct material, and overhead. Second, these figures must be distributed to various units such as products, processes, producing divisions, and operators. Third, appropriate cost reports must be compiled for the various executives concerned. Finally, the re-

sults of performance as disclosed by the cost reports must be reviewed in the light of the original objectives. This may lead to modifications of previous decisions, or new decisions by the executives concerned. It will be seen that these steps correspond to the phases of comparison in the organic function of control.

The data supplied by cost systems may serve several purposes. Such data are helpful in determining the operating effectiveness of the several levels of the organization. A correctly developed cost system makes it possible to compare actual with standard costs. It makes it possible to estimate production costs by items of expense and kinds of products. Cost data are useful in determining the probable limits of cost variances for planned operations. Finally, a cost system is a source of other statistical information concerning expenses and costs.

There are certain requirements for the operation of a cost system. Cost units, whether they be organization divisions, production orders, processes, or operating periods, must be carefully determined and described. Incurred expenses must be allocated to the prescribed units on equitable bases. Much of the accuracy of a complete, careful collection of expense data can be destroyed by an arbitrary rule for the allocation of overhead to factory orders. Account classifications should parallel the divisions of the organization so that comparisons can be made readily. Cost reports and statistical information should be available promptly to have managerial value. These figures must be not only current but also comparable with those for past periods, previously determined standards, or contemplated budgets. Cost data should be adequate for the determination of what expense variations from cost and budget standards have occured in which departments. They should indicate the causes of variances, within the limitations of accounting data. The determination of specific causes must be made usually by the responsible line executive. It may be made for him by the technical staff executive who has staff responsibility for the general class of problems within which the particular difficulty falls. The system should be operated by skilled accounting personnel to insure the correctness and significance of the cost data. The cost accountant must be sufficiently familiar with manufacturing operations to be able to deal with them in the way most helpful to the line executives. It may be necessary to educate operative executives in the use of the cost information and reports that are provided by the accounting department. The use of cost data should be reviewed periodically to eliminate needless reports and to determine what additional cost data might be profitable. The cost

system should be an integral part of the general accounting system. Finally, the expense involved in operating the cost system should be commensurate with the managerial value of the information produced.

The Nature of Product Costs

The production of goods and services involves expenditures for the requisite factors of labor, materials, burden, and other items of expense. Some of these expenses may vary proportionately, less than proportionately, or not at all as output increases. The manner in which they vary, and the extent to which they can be allocated directly to production units determine largely whether they are direct or indirect expenses. The cost of some materials, such as filler used in the manufacture of a desk, for example, increases proportionately with output. It is treated as indirect expense, nevertheless. It would be too expensive to determine exactly how much filler was applied to each desk. Other expenses, such as janitor service and plant maintenance expense do not enter directly into production. Such costs are called indirect, burden, or overhead expenses. These expenses are distributed over the units of output by some appropriate method of proration. Methods for distributing overhead expense will be discussed below.

The costs incurred for the factors of production are allocated to the various prescribed cost units by the cost accounting procedure. To accomplish this, records must be kept by divisions of manufacturing activity, production orders, and detailed cost elements. Duplicate reporting of the same basic information is an unnecessary expense. The original product cost information is needed for production control purposes. The production control department must coördinate the use of materials and the time of men and machines with the requirements of production orders. Much of the original cost information concerning direct material and direct labor charges is a by-product of the production control system. This assumes that the latter system is well developed.

Direct material charges include the costs of those materials which enter directly into the finished product provided that the amounts and condition of use by a particular production order or product can be determined accurately. The charges for indirect materials are first collected by the departments that used these materials. Similarly, direct labor is charged to the specific order to which it was applied. Labor cost summaries by departments may be kept for comparison with budgets. Indirect labor is treated as an indirect expense. The overhead or burden represents the proportionate share of all indirect expenses of manufacturing.

The cost of any given unit of output is thus made up of various kinds of incurred expense. The relationships may be summed up as follows:

Direct material + Direct labor = Prime cost
Prime cost + Factory overhead = Factory cost
Factory cost + Administrative expense = Cost to manufacture
Cost to manufacture + Selling expense = Cost to sell
Cost to sell + Profit = Selling price

It is public policy in the United States to insist on the establishment of fair prices in free markets, under competitive conditions. The public cannot be expected to reimburse the company for ill-advised expenditures, mistakes in interpreting market trends, or other errors in managerial judgment. There are favored pressure groups, of course, which have been exempted by legislative action from strict conformity with the law of supply and demand. The prices charged by these groups for goods or services accordingly tend to be monopoly prices temporarily. Costs do not immediately determine free market prices, however, except when customers have no alternative sources of supply. The cost to sell, or the total cost, is the basis, nevertheless, on which prices are estimated in industries in which a market price is not available. It enables management to decide whether orders will be profitable when prices are normally determined by market conditions.

Classes of Costs

There are two types of costs, historical and prospective. Historical or collected costs show what has been the direct and indirect expense of manufacturing definite quantities of each kind of product. They are collected by the cost department from reports made out as the product goes through the various stages in its manufacture. The total cost of the product that is covered by a particular production order cannot be computed until manufacturing has been completed. Comparison with the previous costs of the product will show whether the cost of a given quantity is reasonable. It will not make possible any action to hold the present cost within reasonable limits, since manufacture is completed. It may indicate what is necessary to prevent high costs in the future, nevertheless.

Prospective costs show, in advance of manufacturing, what the cost of the product should be. These costs cannot be determined, obviously, on the basis of actual current expenditures. Such costs are computed by using cost standards based on past production or scientific analyses. They permit manufacturing expenditures to be anticipated and to be checked as manufacturing proceeds. These costs furnish a more satisfactory basis

of comparison with collected costs, because the costs of previous orders may have been incurred under conditions materially different from those representing good performance. Prospective costs are more truly a standard of accomplishment.

Historical Costs

The basic cost elements mentioned above are common to both historical and prospective costs. The methods of determining them differ significantly, however. Historical or collected costs will be discussed first.

Direct Material Charges

Two types of expenditures for materials enter into the cost of the product—those for direct and for indirect materials. Direct materials are those which enter directly into the manufacture of the product and which can be definitely identified with the production of a specific quantity. They become a part of the product in most instances. For example, the number of feet of steel stock required to make a given part can be determined accurately, withdrawn from steel stores, and charged to the order number for that part. The tools used to machine the steel stock may be charged to the order number as direct materials only if they are entirely used up in making the requisite number of pieces.

Indirect materials are materials which enter into the manufacture of an order but cannot practicably be allocated to that order—for example, oil, waste, or other departmental supplies. It is desirable, whenever practicable, to charge the material used for a given quantity of product to the order for that quantity, because this aids in establishing a closer control over the use of materials.

The cost problems in plants in the same industry may be similar in general, but it is improbable that they will be exactly alike, because of individual differences in production methods. Therefore one cannot expect to find a standard method of collecting direct material costs. In the majority of well-managed plants, a manufacturing order is issued when a given quantity of a product should be manufactured. This order, which authorizes the production division to fabricate the quantity, is usually issued on the authority of the manufacturing program, a manufacturing requisition originating from the balance of stores books, or a specific sales order. Under the authority of the manufacturing order, various production orders and suborders will be issued authorizing the manufacture of the component parts which make up the product, and the operations which must be done on these components. The exact method of authoriz-

ing these various activities will depend on the production problems and the production organization and methods. The production control department will make out the necessary papers and forward them to the shop in accordance with its production schedule. It will forward to the cost department a copy of the manufacturing order, or what corresponds to it; this serves as notice for this department to make out a cost sheet for the order.

Among the production papers which must be made out are requisitions authorizing the withdrawal from stores of the material for the order. The name, symbol, and description of the material, and the order number to which it is to be charged, are entered on the requisition. The requisition is sent to the storeroom. The material is delivered to the department, the storeroom forwards the requisition to the balance of stores department, which enters the withdrawal of the material on the stores ledgers. On the basis of the requisition, the stores account for the material is credited with the value of the quantity that has been withdrawn, and the order number is charged with a corresponding amount. In some cases the unit price of the material may be entered on the requistion from the stores ledger; in others, it may be entered in the cost department. The balance of stores department forwards the requisition to the cost department, which posts the total value of the materials withdrawn to the cost sheets for the order.

Frequently the total quantity to be manufactured is broken up into relatively small lots for convenience in controlling production. This is done particularly in the case of a standard product which is manufactured in large quantities, and for which a considerable time is required. In such cases finished product would be delivered to stores before the total quantity in the order was completed. A stores credit is made out when material is returned to stores. A special form of stores credit—one that can be easily distinguished—is used when finished product is put into stores. Its function is to credit the order with the cost of the quantity delivered, and to charge finished stores with the corresponding amount. These credit slips go to stores with each delivery of the finished product, and are forwarded by stores to the balance of stores department. Here they are posted to the stores ledgers, and are then forwarded to the cost department. Inasmuch as the deliveries have been made before the completion of the entire order, they must be charged to stores at the unit price of the last order. The costs of the last order probably will not be the same as the costs of the current order. The inventory records must be adjusted for the discrepancy when the order is finally closed out.

Direct Labor Charges

It is possible also to distinguish between direct and indirect labor charges. Direct labor includes all the labor that is applied directly to the product, and that can be charged directly to a specific production order number. For example, if a mechanic is to bore, turn, and face a gear blank on a lathe, the time when he starts and finishes this job can be noted, and the elapsed time can be charged directly to the order number for which the blank is being made. It may be impracticable, however, to charge some kinds of labor to a specific order. Such charges are treated as indirect expenses. The only rule that can be laid down is that whenever practicable labor should be charged directly against the product.

In order to collect direct labor costs, the cost department must receive accurate reports of all the labor time that can be charged directly against a given order, product, or schedule. A common means of assuring this, under conditions of intermittent manufacturing, is to give the workman a ticket when he starts a new job. On this ticket, which is variously called an operation ticket, time ticket, or work ticket, are entered his name and number, the order number to which his time is to be charged, the kind and quantity of product, the operation number, and any other information necessary for the proper control of production and costs. The operation ticket thus has as its function to provide:

1. An accurate report of all the labor charged directly against the order
2. Information for checking the employee's efficiency
3. Information for payroll purposes
4. Information for production control

The shop office forwards the operation ticket to the factory office. The employee's efficiency may be computed by comparing the time actually taken with the standard time for the job. If there is a wage incentive system, his bonus or piece-rate earnings on the basis of his efficiency may be computed and entered on the operation ticket.

In large job order plants, a great many operation tickets are forwarded to the factory office periodically during the day. After they are extended, they are sorted by name and the total day's earnings of each employee are posted on the payroll. These earnings may be day work, piecework, or bonus.

Employees are commonly required to record their arrival and exit times on time clocks at the factory or department entrance. When the employees are on a straight day-work basis, this clock time is usually the basis of

wage payment. The total time recorded on the workman's tickets for a given day should equal the length of the work period unless he has been absent or tardy.

The postings to the payroll constitute credits to the employees. To keep the books in balance, there must be a corresponding charge against the orders on which their labor has been expended. For this purpose the operation tickets are forwarded to the cost department. It sorts them according to the charge symbols on them. A cost clerk posts the total labor charge against each symbol to the cost card for that symbol.

This breaking down of the operation tickets into the various charge symbols is sometimes done in the factory office rather than the cost department, as part of the work of compiling reports for the production division. In this case, summaries of charges against each order are forwarded to the cost department at the end of the week together with supporting job tickets.

The direct material and direct labor charges have now been collected on the cost card for each order. The amount of indirect expense to be charged against each order must be determined before the costs can be complete.

Indirect Expense

Indirect expense includes all items of expense that are necessary for the conduct of manufacturing operations but which cannot be charged against any particular production order. It includes many items of an intangible nature, such as depreciation charges for buildings and equipment, that at best cannot be charged off against individual orders with any great degree of accuracy. For this reason, unduly refined methods of collecting and distributing indirect expense should be avoided.

Indirect expense can be considered as being made up of indirect material charges, indirect labor charges, miscellaneous controllable expense, and fixed charges. To some extent the company can control the first three because they tend to fluctuate in some degree with changes in the volume of production. The degree of their increase or decrease is less than the corresponding changes in production. Variations in the volume of production have little effect on fixed charges. It will be necessary to pay about the same amount of taxes on land, buildings, and equipment, whether 1 or 10,000 units of product are made. The fluctuations in controllable indirect expense with corresponding variations in production, on the other hand, can be predetermined within reasonable limits. The

organization should be held responsible for keeping these expenses within these limits.

An adequate, comprehensive classification of accounts is necessary to control indirect expense and account for it properly. Such a classification should define clearly the scope and character of the various accounts. There is otherwise likely to be little uniformity and accuracy in making expense charges. The classification should be one that will lend itself to managerial control. There are various items of controllable departmental expense, for example. Cutting oils, cotton waste, and other indirect materials have been mentioned previously. The wages and salaries of foremen, shop clerks, machine adjusters, and truckers are examples of indirect labor expense. Miscellaneous controllable expense items include departmental charges for power, light, machine repairs, scrap and rework, and others. The standard classification of expenses for a manufacturing department may include a dozen or more major expense items. The amount and frequency of the expenditures, and their significance under the particular conditions of manufacturing, will govern largely the departmental classification in a particular company. Executives should receive periodic reports on controllable expense by classifications and departments. A copy of the report for a particular shop department should be sent to the foreman of that department.

The various items of indirect materials, indirect labor, miscellaneous controllable expense, and fixed costs are usually collected and grouped according to the major divisions of the organization. Under the head of general factory expense there will undoubtedly be an account for factory office expense; and under this, probably subaccounts for clerks' salaries, executives' salaries, office supplies, and similar items. These expenses should be broken down by office departments. These departments are usually staff organizations. Administrative and selling expenses should be broken down similarly. Reports of departmental and divisional expenses should be shown in comparison with corresponding budget standards, of course.

The original sources of information on indirect expenses are material requisitions, operation tickets, vouchers, and purely book transactions. These papers go through various channels to the cost department, where they are collected under various expense accounts.

When it is necessary to pay such expenses as interest, taxes, insurance, rent, and similar items, a voucher authorizing the writing of a check is usually originated. These vouchers are the basis for charging these items

to the proper expense accounts. There are a number of indirect expenses, such as depreciation costs, which are not charged on the authority of operation tickets, requisitions, or vouchers. Charges for them result from purely accounting transactions. However, the principle of handling them is the same as far as costs are concerned.

The Distribution of Indirect Expense

The intangible nature of a great many of the items that compose the indirect expense of manufacturing makes it practically impossible to devise any method of distribution that will be exactly accurate. For this reason, the simplest system that will give reasonable accuracy in cost finding is the most desirable. Costs are a tool for managerial control. Unless the increased accuracy will pay for itself in the savings which result from better control, it is usually not warranted. Beyond a certain point, the expense of operating the cost department increases more rapidly than the benefits from increased accuracy. It is easy to pass this point of diminishing returns without realizing it.

The indirect expense of manufacturing may be one of the largest items in the cost of manufacturing. The selection of proper methods for its distribution is accordingly an important problem. Most methods prorate indirect expense over product accounts or production orders on the basis of the direct labor cost, direct material cost, the time required to complete the order, or a combination of these factors. Some of the methods which have been used for proration are discussed in the following paragraphs.

The percentage-on-direct-labor method assumes that the amount of indirect expense varies proportionately with the direct labor cost on a given production order. The percentage of total indirect expense to total direct labor is computed from the actual figures of the preceding accounting period (or the average of past accounting periods). This is then applied to the direct labor costs on each order during the next period to determine the share of indirect expense that should be charged to the order. The sum of the actual direct labor and material costs plus the computed indirect expense is the cost of the order.

At the end of the accounting period, the computed indirect expense is usually found to be more (overabsorbed burden) or less (underabsorbed burden) than the actual indirect expense for the month. The two figures rarely agree because the prices of the factors of production vary from month to month. The rate of operations is seldom the same as forecast. Indirect expenses do not fluctuate directly with the rate of production, furthermore. Over- or underabsorbed burden must be closed out to an

expense account, and eventually to profit and loss, or the various order costs must be adjusted by means of a supplementary percentage.

The percentage-on-direct-labor method is often used because of its simplicity. It has certain disadvantages, however. These will not be discussed because it is the responsibility of the accounting executive to select and recommend proper accounting methods.

The percentage-on-direct-material method may be used when the direct material cost constitutes the greater part of the prime cost of the product. This method follows the same procedure as the preceding, except that direct material costs are substituted for labor costs as the basis for computations. Most manufacturing companies do not use this method, because other cost factors are usually more important.

Indirect expense may be distributed also on the basis of a percentage of the prime cost of manufacturing. This method affords a broader basis of directly collected costs over which the indirect expense may be prorated. It may be somewhat more accurate when direct labor and direct material charges are normally approximately equal parts of the total manufacturing cost.

The percentage-of-man-hours method does not take adequate account of the workers' varying speed, skill, and use of production facilities. The total indirect expense for an accounting period is divided by the total number of direct man-hours, to get a computed indirect expense ratio in terms of dollars for each direct man-hour. An indirect expense charge is determined for each production order in the succeeding period, by multiplying the number of direct labor hours on that order by the computed indirect expense rate per man-hour.

Indirect expense is more closely related to time expended in producing an order than to direct labor or direct material costs. In cases where there are no great variations in the size and value of equipment, and the volume of production does not fluctuate widely, the percentage on direct labor hours will undoubtedly provide a more reasonable distribution of indirect expense than any of the preceding methods. In addition to relating costs more closely to the use that is made of production facilities and service, this method of distributing indirect expense is not affected by variations in wage rates.

The machine-hour-rate method is intended to get a still more rational distribution of indirect expense. A great many items of indirect expense are related more closely to the size and cost of the machine than to any of the cost factors which have been discussed previously. Such items as rent, light, heat, and taxes can be related to the number of square feet of

floor space that are necessary for the efficient operation of the machine. The interest on the investment, depreciation charges, maintenance cost, and similar items are greater for the large, expensive machine than for the small and relatively inexpensive one. We shall assume that someone wished to rent the use of certain machinery or equipment. It would be necessary then, to determine the amount of the indirect expense that should properly be allocated to the individual items of machinery and equipment. The accountant could not work out a fair and accurate hourly rental charge for each item otherwise. It would be quite necessary, if the equipment varied in size and cost and were used to process work of a varying character. It is no less necessary that such rates be worked out because the company owns and operates the equipment.

The degree of refinement necessary for the machine-hour-rate method depends to a large extent on the character of the business. The principal phases of the general method can be summarized as follows: The normal number of hours which each machine or class of machine is expected to run during a given period is determined. The expense allocated to each machine or class of machine is divided by this number to get the hourly charge that should be made against each order for the use of the particular equipment. In determining rates, all machines, benches, and workplaces must be considered as equipment. If the number of hours run and the expense for the period are exactly the same as those on which the rate was based, expense for the period will be entirely absorbed by production. Indirect expense, or burden, is applied to each order by multiplying the number of hours at each machine by the computed indirect expense rate for that machine.

The indirect expense for a given month will usually be overabsorbed or underabsorbed. The difference between the actual indirect expense and the amount absorbed may be prorated over the orders processed during the month, or charged to a burden adjustment account, as was done under previous methods.

The machine-hour rate method is well adapted to accounting accurately for idle machine time. This is a valuable aid in factory management, for reasons that have been discussed previously.

The production-center method of expense distribution was developed originally by A. Hamilton Church. It is a refinement of the machine-hour rate method. Indirect expenses are collected as far as possible according to the particular departments that incur them. In some instances, a series of expense accounts is set up for each shop, to which its indirect operating expense is charged. In addition, other indirect expenses of manufacturing

are analyzed to determine what items can be allocated directly to each department and what must be prorated to them. Depreciation and interest charges for machinery can be directly allocated on the basis of the character and value of the machinery and equipment in each department; the power used to drive it can be metered. However, there are many items that must be prorated. Interest, depreciation, and other expenses connected with land and buildings can be prorated over the different departments on the basis of their floor areas, as can the expense of heating and lighting. The various items of general indirect expense must be analyzed to determine the best basis for prorating them over the various departments.

The equipment in a department is divided into a number of production centers. A production unit may be a single machine, a group of machines of the same class, a group of machines not of the same class but used for a specific process, or merely a workplace, such as a bench. Each production unit, with the floor space necessary for its operation, is called a production center.

When possible, the indirect expense of the department is allocated directly to each production center. Interest and depreciation charges on the machinery and equipment in each production center can be charged directly against the center. The department's power charge can be prorated over the equipment on the basis of the rated horsepower of each machine. The general indirect expenses that have been charged to the department can be prorated over the production centers on the basis of the floor space required by each one. An annual charge for the services of each center can be determined, when all the indirect expenses have been broken down against it. An equivalent hourly rate can be determined, knowing the total number of machine-hours that the center is expected to run during the year. This is the basis for a charge against orders using the center's facilities. The charge is proportionate, of course, to the time duration of use of these facilities by a particular order.

Closing out the Order

Some notice that the order has been completed must be forwarded by the production department to the cost department under conditions of intermittent manufacturing. Upon receipt of such notice, this department must check the cost card for the order to see that all cost data have been received and recorded. The final cost of the order is then figured, and the card is removed from the active file of cost cards.

Summarizing Costs

It is helpful to compare the results for a given order with the trend of costs for the particular product item. The final cost may be entered on a comparative cost card. Such a card shows the relation of the cost of the order to that of previous orders. Important changes in cost trends should periodically be brought to the attention of the managing executive. It may be more effective to present these trends graphically, of course.

Prospective Costs

Prospective costs are intended to show in advance what the costs of the product should be. There are two types: standard and predetermined. The latter term is used for cost estimates for a forthcoming period or a prospective order. Such estimates are prepared for purposes of judging financial requirements, establishing expense budgets for the operating divisions, and providing a basis for quoting prices on requests for bids. Although predetermined costs may be derived from cost records and summaries, they are not an integral part of the accounting system, nor do they go through the steps of the cost accounting process. Rather they are a form of statistical information. Cost estimates should be based on time-study data, bills of material, studies of spoilage, interpretations of indirect expense variations, and other cost records, modified by probable economic developments during the period for which they are prepared.

Standard-Cost Methods

Standard-cost methods are cost accounting methods which involve the usual steps of the accounting process. They tie in with the general accounting records. Standard costs may be defined as the costs of commodities or of production which are determined by computation from the manufacturing specifications for material, labor, and burden at normal rates.

Specific installations of standard-cost systems vary in extent and detail. The general steps are basically the same. The fundamental requirements for standard costs include the careful establishment of standards of condition, personnel, procedure, and performance, material usage per unit of product, labor requirements, and the share of normal overhead expense. Next, there must be a method of computing standard material, labor, and overhead costs. There must be a method of allocating them to production orders and operating divisions. Concurrent records of actual costs should be kept. Variances of actual from standard costs should be determined. Analyses of variances should be made. Summaries should be prepared by

divisions and products in the detail necessary to facilitate the discovery of the causes of variances. The standards themselves remain constant from period to period unless there are significant changes in price trends, operating conditions, products, or management policies.

Standard costs are a practical application of the exception principle. Significant performance variances from standard only are reported to the responsible operative executives. These executives ascertain and eliminate the causes of the variances. The absence of significant variances assures executives that manufacturing operations are proceeding satisfactorily, in so far as expense is concerned.

The establishment of standard material costs must be preceded by the determination of the standard quantities of materials used in the various products and of the standard unit material price for each material. The quantity standards are drawn up from engineering material specifications, material lists, standard parts charts, standard mixture formulas, and product drawings. The price standards are usually based on average prices for a past period, current prices, or estimates of future price trends submitted by the purchasing department. The standard quantity of material per unit of product multiplied by the standard material price gives the standard unit material cost of that particular kind of material. This cost multiplied by the predetermined number of units on any given order gives the standard material cost of that order; and the sum of the various standard material costs in turn equals the total standard material cost.

Standard labor cost accounting is complicated because of the various purposes which labor records serve. There is usually more than one wage payment plan in a given plant, furthermore. The basic requirements for standard labor costs are the careful determination, by means of time studies, of the standard allowed time for each operation. The base wage rates for each operation must be established. The labor cost standard may be expressed in terms of standard hours and standard wage rates per hour, if day-work wage plans are used. This must be increased by the standard incentive rate and adjusted for standard operating efficiency, if an incentive plan is used.

The necessity of establishing bases for allocating capacity utilization and of determining its "normal" rates, makes it difficult to determine indirect expense standards accurately. Indirect expense studies based on past records, engineering specifications, and other available data are made. These show how each item of expense varies with operating activity. Such studies permit the comparison of actual expenses with budgeted

expenses on the basis of the same rate of operative activity. The next step is to determine the projected operating rate for the subsequent accounting period. The normal or standard capacity for the period can than be determined. It is then necessary to decide which method (percentage on direct labor, etc.) should be used to distribute the total of the indirect expenses to the operating divisions, production centers, and production orders. Underabsorbed normal burden or overabsorbed normal burden may be closed out to profit and loss directly, or to the production orders. After the orders are closed out, cost summaries similar to those for material and labor are prepared to aid in the analysis of causes of variations.

Causes of Cost Variations

Cost summaries provide the basis for determining the causes of variation between standard and actual costs. When the causes are known, the responsible line and staff executives must take the proper corrective action. Changes may be required in operating methods, processes, purchasing policies, inventory, control, or personnel policies. Cost standard variances are set on the basis of careful study of organizational and physical factors underlying costs. These studies are made usually by some competent technical staff department outside of the financial division. The physical bases of costs may remain fixed for long periods, except for the effects of technological progress. The cost standards that are built on these bases are expressed in dollars, of course. They change when price levels change significantly.

There are many causes of cost variances. Variations in material cost may be due to the following:

1. Changes in purchasing policies or practices
2. Changes in market prices of raw materials
3. Changes in the design of products, machinery, or tools
4. Changes in methods of processing or fabricating
5. Changes in the quality or kind of materials used
6. Excess spoilage of materials during production
7. Shrinkage of raw material inventory, goods in process, or finished parts
8. Damage during handling
9. Too rigid inspection
10. Other causes.

Labor cost variances may arise from any of the following:

1. Poor selection of workers
2. Inadequate or incorrect training
3. Low level of wages or an ineffective incentive plan
4. Lack of suitable materials, machines, or equipment

5. Changes in the design of the product
6. Changes in machinery, methods, or specifications
7. Unsatisfactory working conditions
8. Dishonesty among workers or collusion with supervisors
9. Excess supply or idle time of labor
10. Other causes

Causes of variances in indirect costs may be found in the following:

1. Lack of work
2. Lack of adequate staff services for operative employees
3. Lack of instructions
4. Lack of power
5. Lack of tools or equipment
6. Lack of materials or supplies
7. Machine breakdowns
8. Machines not set up promptly
9. Excess time taken on the job
10. Other causes

Management is at fault in most cases, because of improper planning or performance of other management functions. The analysis of variances aids in determining accountability for the costs of variances. It is facilitated by the development of cost variation formulas that indicate what cost aspects of these variances are due to time, rate, and utilization of cost factors. The methods, as well as the extent of the analysis, can be expanded to whatever degree is practicable in the light of possible savings. Specific, detailed, technical analyses of cause and effect must be made by the appropriate staff department, as noted above.

Internal Auditing

The auditor's section may be a component element of the comptroller's department. It should be independent of the accounting section, and at least coequal with it. The auditor reports directly to the chief financial officer, in some companies.

The auditor's work is primarily an inspection function. It is somewhat similar, within the financial organization, to the inspector general's function in military organization. The auditor's work should not be merely a detailed, clerical checking job, certainly. Each branch and unit of the accounting section is responsible for the accuracy of its work. The branch is expected to set up the necessary internal checks of its work. The principal auditing functions are, accordingly:

1. The inspection of accounting and financial records, and the verification of financial data

2. The initiation of appropriate action, through designated channels, when evidences of unauthorized dissipations of funds, or other financial derelictions, are discovered
3. Determination of the degree of compliance with financial policies and procedures
4. Evaluation of financial policies and procedures with a view to determining the protection for company financial interests that they afford. The development of more economical and effective office procedures is the responsibility of the office manager, of course.
5. Recommendation of studies of opportunities for improvements in financial policies and procedures as disclosed by the results of audits

There is a function of external auditing. Most concerns employ some firm of certified public accountants to make a periodic inspection of the company's books. This may be done annually or more often if necessary. Such an external audit may be required by the company's bylaws. It may be required by the company's bankers for use in granting credit. Top management may consider it a good investment to pay for a competent outside opinion of accounting and fiscal operations, when large sums of money are involved. External auditing does not imply any lack of confidence in the integrity or ability of the auditor.

Budgetary Planning and Control

Budgetary control involves a comparison of actual results with estimated expenses required to accomplish designated sales and profit objectives. These estimated expenses are predetermined for the performance factors that are required for the attainment of these objectives. Such estimates, when approved, become the budget standards. Budgetary control assures that expenditures, beyond those authorized by an approved budget, will not be made without the concurrence of the finance committee and the approval of some designated general executive. The budget director's office determines the causes of significant variances from budget standards. It recommends appropriate corrective action. A statement is prepared by this office for each organization unit, indicating the estimated expenses for contemplated projects. The subsequent review of actual and estimated expenses provides the basis for measuring the effectiveness and economy with which the particular unit has attained its objectives.

An effective control of operations, financial or otherwise, must rest on approved operating plans. These are the plans of the company's organic divisions: production, distribution, and finance. They include the plans of their supporting staff divisions. The nature of these plans has been discussed previously. The various expenses required for the completion of

these plans are estimated by departments and divisions, and then by their programs. Comparison of actual expenditures is made periodically with budget standards. Each executive is responsible for economical conduct of his operations in the completion of approved plans. Budgetary control is an important means of establishing accountability for a satisfactory discharge of this responsibility for expense. It is evident, however, that such a budgetary control depends on budgetary planning.

The company may have a budget committee which passes on budget objectives and policies. It may be a subcommittee of the finance committee. This committee studies the budget proposals of the budget director. It can recommend approval of the proposals in whole or in part. The budget director reports usually to the comptroller or the chief financial officer. Budgetary planning and control are organizational approaches to the management of expense, however. It is a financial phase of administrative management, obviously. Cost control, on the other hand, is a project approach to expense management. It is a financial phase of operative management. The budget director reports to the vice-president for administrative staff services in some concerns, for these reasons. It is a financial staff function, nevertheless. It is the duty of the administrative staff vice-president to coördinate administrative planning and control, not to do it. His needs can be served largely by participation in planning meetings, and by the provision of reports by other offices. The budget director reports accordingly to the comptroller, in the organization shown in Fig. 29.1.

The Objectives of Budgeting

The objectives of budgetary planning and control are the values that justify it. Budgets raise the quality of creative planning because the basis of action is expressed in objective and statistical terms. They make administrative executives more careful in making plans, because these plans must be expressed in definite form. The first drafts of operating budgets are invariably originated by the operative executives whose work is to be measured by them. This promotes coöperation with administrative executives; and the support of their plans by operative executives. The necessity for forecasting sales and the required amounts of the various production factors impresses on these executives the importance of effective planning methods. Operative executives receive plans expressed in unequivocal financial terms; this fosters a definite division and allocation of responsibility. Administrative executives can make fairer decisions because they have a financial standard of performance by which to interpret

the reports of actual results. Operative executives can use their own initiative within the permissible limits of variance from predetermined standards of performance, in executing their responsibilities. The evaluation of variances from budget standards gives a basis for determining their causes, and for eliminating them in future plans. The necessity for establishing budgets on the basis of organization divisions may lead to a study of the organization structure itself, resulting in its improvement.

Phases of Budgetary Control

The procedures for determining, establishing, and utilizing budget information vary from the simple to the very complex. The essential steps in any procedure can be differentiated. The details of these steps depend on the size of the company, the complexity of operations, and the desired results. These are developments usually of the following phases:

1. Forecasts of expected sales and production are made for definite periods in the future. These periods conform to the usual planning periods. Monthly, quarterly, and annual budgets are commonly made.
2. Determinations of the quantity of each kind of production factor required for the projected sales and production are derived from plans.
3. The required units of the various production factors are converted into monetary units or expenses.
4. Estimated expenses for the organization as a whole are subdivided into divisional, departmental, and production center expense statements.
5. Conferences on proposed budgets are held with departmental and divisional executives. These are the executives who initiate expenditures. They must accomplish their missions within the limits of budgeted expense for their respective organizations. It may be necessary to modify budget proposals in the light of this requirement. The success of the budget director depends, in any event, on his ability to get the understanding, acceptance, and support of the operating executives who execute the budget.
6. Approved budgets are transmitted to the respective operating executives.
7. Provision is made for collecting information on actual results, by organizational components, in terms comparable to budget items.
8. Variances of actual from budgeted expenses are computed.
9. Analyses of expense variances are made.
10. Recommendations for corrective action are forwarded, through channels, to the responsible executives.

Budgetary control necessarily involves considerable thought, time, and expense for its successful application. It is invariably found that the values more than offset the cost. The degree of refinement should not be carried to the point of diminishing returns, of course.

Budgetary control involves a comparison function of administrative control. It has to do with the control of expenses. The principal phases of

the comparison function of control were discussed in Chapter 5. The basic requirements of these phases apply to budgetary control. A close control of expenses requires fast, accurate reporting of expenditures and results in a form that will facilitate budget comparisons. Fast reporting may be necessary, since time is a factor in corrective action. Operative reports are set up on tabulating punch cards in many concerns. They can be run through data-processing machines daily. It is possible, then, to get a daily comparison of actual and budgeted expense, in daily and cumulative totals, by departments and programs. Fast communications and computations are justified only to the extent that they save an amount that is equal to or greater than their cost, however. That speed is necessary which provides sufficient time to correct the causes of significant budget variances.

Types of Budgets

Budgetary control normally involves the establishment of a master budget, and its subdivision into as many divisional and departmental budgets as are desired. Among the more important divisional budgets are those for sales, advertising, production, labor, purchasing, material, and indirect expense. The sales budget is the basis for the others, and consequently its preparation requires the utmost care.

The sales forecast is studied in the light of available plant capacity, profit possibilities, and current inventories. The sales and production budgets are then drawn up. The production budget is thus coördinated with the general sales budget and other relevant data. A purchase budget is prepared from the production budget, materials specifications, use of particular materials by product items, and available data on inventories. This budget shows what is to be purchased, and the quantity and time of purchase. The material budget for the operating division contains information concerning the inventories required to manufacture these items. Labor, material, and indirect expense budgets are in turn prepared for the operating division. The labor budget indicates the kind, amount, and the estimated cost of the labor required to produce the items shown in the production budget. The indirect expense budget contains information concerning the kind, amount, and estimated expenses of the overhead items required in the manufacture of the products in the production program, at the estimated rate of output.

The business conditions that actually develop, as we go through an accounting period, may differ substantially from those that were forecast before the beginning of the period. This may result in changes in sales, expenses, and profits for reasons that are beyond the control of any execu-

tive. He should be given credit or discredit only for the results of forces that he could control. The so-called "flexible budget" procedure provides for the adjustment of budget standards, at the close of a period, to account for those changes in sales and expense factors for which the executive cannot be held accountable.

Business Statistics

The term "business statistics" may include any classified business data, and any statistical comparisons based on them. Statistical functions include the work of collecting, processing, and evaluating facts. The objectives of these functions are informational values. This statistical information should be in a form that will facilitate the management of the business.

Much business data can be taken from the accounting records. The company's statistical unit may be located in the comptroller's department for this reason. Much of the data that is required for managerial purposes is nonfinancial, however. Executives are interested, for example, in the trend of the company's competitive position. This is indicated by ratio comparisons of company to industry sales, or to the sales of the company's principal competitors. Management is interested in trends in new product development for the company and its competitors. Measures of productivity, such as the ratio of physical production to square feet of factory floor space, or production per machine-hour of equipment in place, may show significant trends over a period of time. These and other significant data may originate in the marketing division, the production division, or some major staff division. It may require a person with some training in economic statistics to bring out the significances, furthermore. The function of economic analysis, including business statistics, has been placed under the vice-president for general administrative services, in some concerns, for this reason.

A common policy is to permit each department and division to collect and process the information that it requires for the management of its operations, provided that certain requirements can be met. The decentralization of data collection and processing should not result in substantial duplications of clerical work. The particular department or division should be able to process its data economically. Much departmental management data may be processed by a central computing and tabulating unit, when the company has expensive data-processing machines. Such machines require a heavy, continuing load of statistical work for economical operation. Departmental and divisional information for purposes of general

administrative management can be forwarded to the administrative vice-president in processed form. Financial analyses are made accordingly by the finance division for its own work of accounting and finance. This work is done usually by an analysis and control unit under the comptroller. Copies of analysis reports are sent to the principal financial executives and to top management.

Financial Analysis

Financial analysis is broadly the function of evaluating any financial data. The term is often used narrowly to mean the evaluation of the data presented by the company's financial statements. The objective of financial analysis is financial information that will assist management in planning, organizing, and controlling the activities of the business. This information should throw light on the condition, status, and progress of the organization, relative to the general economy, the industry, and principal competitors.

There are various techniques that are used by financial analysts to accomplish the above objective. The more common are (1) financial ratio analysis, (2) analysis of the source and application of funds, (3) the use of 100 percent financial statements, (4) break-even chart analysis, and (5) the use of the so-called "duPont formula." Financial ratios are merely expressions of significant relationships between certain items in the company's financial statements, or books of account. Some of the more common are the ratios of current assets to current liabilities, net profits on sales, net profits to net worth or tangible net assets, net sales to net working capital, net sales to inventory.[5] Such ratios indicate the company's financial and business status when compared with like ratios for its industry and its competitors. They indicate direction of progress when computed for a series of years, using comparable financial statements. Such ratios enter directly into financial planning. Detailed operating plans for coming 3-months, 6-months, and annual periods should be costed by product lines, plants and divisions, and the company.

Projections of the source and application of funds can be made on the basis of the company's financial statements for a past period of years. This is merely a method of showing the changes in balance-sheet items between successive periods to indicate the release or absorption of

[5] *Dun's Review and Modern Industry* publishes periodically "Fourteen Important Ratios for 36 Manufacturing Lines." Similar ratios can be computed for a company's competitors, using their published financial statements. See also Roy A. Foulke, *Practical Financial Analysis*, McGraw-Hill Book Co., Inc., 1953.

percent or more of these profits into the business. There would be left approximately 3.8 percent on total tangible assets for distribution to stockholders, in such case. This rate of distribution should mean a much higher rate on net worth, of course. It should be noted that the plow-back of 5.8 percent on total tangible assets also means an increase in the stockholder's equity, and a possible capital gain when he sells his stock. This example also illustrates the inflationary effects of high corporate income taxes during a period of inflation. The value of the duPont formula in financial planning is evident. Its use in long-range planning will be seen when we look briefly at this problem in Chapter 31.

The above techniques for financial analysis are merely a sample of the methods that are available to the company's financial executives. The application of these methods aids the treasurer in financial planning and the work of financing. Their application to current results assists the comptroller in operating the company's staff financial controls. The resulting reports assist the vice-president for general administrative staff services in the interdivisional coördination of administrative planning and execution. They assist top management accordingly.

Internal Financial Control

The function of internal financial control is a distinct phase of the comptroller's work in some companies. It is concerned with the coördination of the organization's efforts to accomplish its objectives, in so far as coördination depends on financial analyses and evaluations. The recent concept of the function includes financial planning, as well as the financial control of current operations.[7] It is obviously a financial phase of general administrative management. Much of this work has been discussed previously in this chapter. It has been noted also that the function of general administrative staff services has been an outgrowth of the work of the comptroller's department in some companies. The interdivisional coördination of administrative planning and control has been transferred frequently to this staff services group. Financial planning and control have remained in the finance division, of course, except for such coördination. This problem will also be discussed in Chapter 31.

The Office Manager

Office management is the work of planning, organizing, and controlling the activities of an office. The term "office" in manufacturing establishments usually refers to organizations and areas that perform operative staff

[7] See a paper on "Internal Control Applications" by R. L. Ganter, Comptroller, Delco Appliance Division, General Motors Corp. This paper was delivered before the 18th Annual Institute on Accounting, The Ohio State Univeristy, May 17, 1956.

services. We refer, for example, to the purchasing agent's office, the chief engineer's office, the treasurer's office, etc. The office manager is a staff executive, accordingly, in manufacturing concerns. He provides certain professional and facilitative services that assist office executives in the performance of their duties.

The office developed during the middle ages in connection with the work of the "counting house." It was associated with the developing function of accounting. The office manager still works under the general financial officer in many manufacturing concerns, for this reason. We have shown the office manager in this position in Fig. 29.1. The growth and development of staff organizations in manufacturing concerns have become so great, however, that the office manager is not particularly a financial executive. He may be placed in the finance division, nevertheless, for administrative convenience. The office management functions present major problems in modern business. They will be discussed in Chapter 30.

The Credit Manager

Credit management is not a function of the comptroller's office. It is found under the treasurer's office in some manufacturing company's.[8] The securing of credit for the organization is a phase of the provision of capital. It is obviously a financial function. The granting of credit to customers is a marketing function in most manufacturing organizations. The credit manager is concerned with the granting of credit and the collection of past due accounts. It has been suggested accordingly that these functions should be assigned to the marketing division. Their performance should be subject to the general financial policy, as formulated with the concurrence of the finance committee. The credit manager's operations must be tied in procedurally with the accounting and fiscal operations of the financial division.

PROBLEMS

1. The Company's sales objective, at the end of the coming 5-year period, is \$45 million annually, for all product lines. The present capital turnover rate is 1.5 turns per year. It is expected that this rate will not be improved greatly. The ratio of fixed assets to total tangible assets is approximately 52.0%. This ratio also is expected to remain approximately constant, despite increasing automation of factory operations. The company has at present \$11 million of fixed assets. It is expected that normal replacements of machinery, equipment, and buildings will be covered adequately by the rates of depreciation and obsolescence that have been established by the comptroller's

[8] E. I. duPont deNemours, to which reference has been made on p. 871, is one of them. Davis, *op. cit.*, p. 5, Fig. A.

division. Our present rate of profit on total tangible assets is 10% before taxes. An objective of the company is 20% on such assets by the end of the coming 5-year period. The company's corporate income tax rate is 50%. The company's top management has assumed that this will continue to be the rate during the coming period. It is the company's policy to pay out approximately 60% of its profits, after taxes, to its stockholders in the form of dividends.

(a) Estimate approximately how much additional fixed capital must be raised through external financing to support the projected expansion of physical facilities.

(b) What are the possible causes of error in your method of estimating capital requirements for fixed assets?

(c) How would the chief financial officer get a more accurate estimate of such capital requirements, as the organization approaches the end of the 5-year period?

2. A cost analysis of Order #1682, for 500 pieces of Part #1280, has been made to check out our standard production costs. The following is merely a brief summary of the results:

Cost Factor	Standard Unit Costs	Actual Unit Costs	Cost Variances	% Variance
Direct Material	$ 4.00	$ 4.40	$0.40	+10.0
Direct Labor	6.00	6.90	0.90	+15.0
Prime Cost	$10.00	$11.20	$1.30	+13.0

(a) What would be some of the causes of the variances in direct material costs?

(b) What could be some of the causes of the variances in direct labor costs?

(c) Are you going to theorize about these causes, or find out what they are? How will you proceed, in the latter case?

(d) Factory overhead expense is distributed at the rate of 80% on direct labor, to get factory costs. Would the above method of distributing overhead expense tend to result in overabsorbed or underabsorbed burden charges in the above case? Why?

(e) The chief financial officer has concluded that the company's labor costs are high, as compared with corresponding costs of our competitors. Investigation of the causes suggests that the factory management has not kept abreast of the development of automation in the industry. What changes in our cost accounting methods may be caused by a substantial development of automation in the factory.

3. A liquid coolant is used frequently in the operation of metal-working machines. A stream of this liquid plays on the point of the cutting tool as the machine performs an operation on a piece of material. Assume that these are direct materials, used in making a production part. The coolant enters directly into the performance of primary operations in such case. To what type of account would you charge the usage of such coolant? Why?

CHAPTER 30 •

• Office Management

The Development of Office Management

OFFICE management began to be recognized as a separate and distinct phase of management at the turn of the twentieth century. The origins of the office can be traced back to the beginnings of written records, of course. Its development during the middle ages was associated with the developing accounting profession. Its modern development was begun by W. H. Leffingwell, Harry Hopf, and certain other pioneers in the field of scientific management.

There has been a continuous increase in the size and complexity of the business organization since the beginning of the century. This increase has been both a cause and an effect of increasing *per capita* production in the United States. Staff organizations have grown as fast, or faster, than the growth in number and size of business organizations. This staff growth has been necessary to provide the required managerial specialization. An office, in manufacturing establishments, is a place where certain staff functions are performed. There are in large establishments the office of the company's legal counsel, the personnel director's office, the advertising manager's office, the engineering office, and many other offices. Such staff functions support the primary functions of management. The operative functions of staff departments are performed by clerical operatives for the most part. There is an increasing proportion of professional operatives in these offices, however. Much of the work that such people perform in large companies must be done by line operatives and executives in the very small plant, or it is not done at all. These staff operatives work under the immediate direction of staff executives, of course. The increase in the number of such people has been the result of a necessary increase in staff planning and control functions. Top executives cannot manage the primary operations of large companies by personal direction and supervision. They must work through their immediate subordinates. They require the assistance of staff conferences and staff reports.

This development of the staff function in business is reflected in the growth of the work force that is employed in offices. This force has increased at the rate of 6.5 percent per annum, approximately, since 1940. Littlefield and Peterson say that "about one worker in eight is now an office worker. In 1900, the proportion was about one in forty."[1] This rate of growth has taken place in spite of the increasing mechanization of office operations. There are certain developments, however, that tend to distort the significances of such growth figures. One is the growth of "big government." An increasing proportion of our working population has been employed in governmental offices. Another development has been the mechanization of line operations in manufacturing plants. One of the objectives of such mechanization is a reduction of the direct-labor hours required per unit of product. One would expect operative staff/line personnel ratios to increase when the mechanization of line operations proceeds farther or faster than the mechanization of staff operations.[2] The staff/line personnel ratio was approximately 75 percent for the average Ohio manufacturing concern in 1954.[3] The average company has a staff office payroll that is evidently an important cost factor. The expense of office operations includes more than office payroll, of course. It is overhead expense, regardless of what it includes. Excess staff expense reduces the profitability of operations. Insufficient staff expense reduces competitive effectiveness. The manufacturing executive should be interested greatly in office management for these reasons, and he usually is.

This interest has been stimulated also by the necessity for increasing investments in office machinery and equipment. Executives need more business information for planning purposes, and they may need it faster for control purposes. A large-capacity electronic computer may cost more than a million dollars. A few large corporations have them. Most manufacturing concerns do not. Their investments in office machinery may be large relatively, however.

The Function of Office Management

Office management is broadly the function of planning, organizing, and controlling the work of an office. The executive in charge of this office has the immediate responsibility for the effective, economical management of

[1] C. L. Littlefield, and R. L. Peterson, *Modern Office Management*, Prentice-Hall, Inc., 1956, p. 5.

[2] A. W. Baker, and Ralph C. Davis, *Ratios of Staff to Line Employees and Stages of Differentiation of Staff Functions*, Bureau of Business Research, Ohio State University, 1954.

[3] *Ibid.*, p. 15.

its work. This executive may be the purchasing agent, the chief engineer, the personnel manager, the chief accountant, or some other staff executive. These men are interested in the objectives of their particular departments, and in the work of accomplishing these objectives. They may have had professional training in their staff fields. They may have little interest in the design of clerical procedures. They may be more interested in solving the problems of their particular professional field than they are in the details of the clerical work that underlies such solutions. Such work is a major cost factor, nevertheless. The office manager aids other office executives in the performance of their management functions, by assisting in the solution of problems having to do with operative clerical production. The office manager does not manage their offices for them, of course. He renders in addition certain services of facilitation to these offices. He is primarily a technical staff executive, in manufacturing establishments, who serves other staff executives principally. The planning and facilitative services of the office manager's department are similar to those performed for manufacturing line operations by the industrial engineering department. The work of the office manager is nonengineering in nature, however.[4]

Staff planning in office management aids other staff executives in such matters as devising clerical procedures for handling clerical projects. It may be concerned with the design of office control procedures. It may assist in planning office organization structures. It determines office standards. The organizing function of office management provides technical advice and assistance in the installation of office procedures, and the development of better office organizations. The office manager's organization may coördinate the flow of office work between staff departments. It may assist in developing and installing internal procedures for the departmental control of clerical production. This organization performs certain other facilitative services having to do with the operation of communications systems, central filing services, central stenographic services, and others of a similar nature.

It is evident that the office manager can contribute many important values to the services of the company's staff organizations. It can often make clerical savings that are the profit equivalents of a large volume of

[4] An AMA survey of office methods, systems, and procedures asked whether the respondents "enlist the aid of industrial engineers from factory and other operating departments in office methods, systems, and procedures work." Approximately 80.6 percent of those responding said that they did not. A majority of the respondents were manufacturers. See the *Management News* of January 1956, published by the American Management Association.

sales. The values contributed to the production of needed staff work of the required quality, at least cost, are the service objectives of the office manager's organization. They are values that are necessary for the efficient, economical management of the business. Some of the more important objectives may be summarized as follows.

1. Technical advice concerning correct office organization and procedure
2. Assistance in installing improved clerical procedures
3. Office conditions that are conducive to maximum economy and effectiveness in the performance of staff functions
4. Efficient communications, mailing, and other office services
5. An effective clerical force
6. A well-coördinated, fast flow of office production between offices
7. Office standards that will contribute to the accomplishment of the above objectives

The Office Manager

The office manager's position has advanced steadily from that of a chief clerk to the status of a major staff executive. His duty assignments have been indicated generally in Fig. 30.1. The nature and extent of these assignments will vary among companies. This depends on the viewpoint of the company's general executives concerning what office management staff work is needed. There are three groups of functions for which the office manager may be given some substantial responsibility in manufacturing organizations. These groups are (1) the planning and installation of office methods, together with the development of supporting conditions, (2) the operation of certain office staff services that are peculiar to office work, and (3) certain activities that have to do with the control of office production. We shall look shortly at the work of the various units, branches, and sections that compose the office manager's department.

The principal product of some nonmanufacturing organizations is an office service. The office manager may have the status of a line executive in such concerns. He is a staff executive in manufacturing companies, as indicated previously. There is usually a personnel manager in such companies. The personnel management responsibilities of the office manager may be limited accordingly. He should be consulted by the personnel department in the development of office training programs, the development of promotional opportunities for office employees, and in other office personnel activities. The office manager has a staff responsibility for the economy and effectiveness of office operations. Personnel is a basic performance factor, of course. Coöperation between the staff

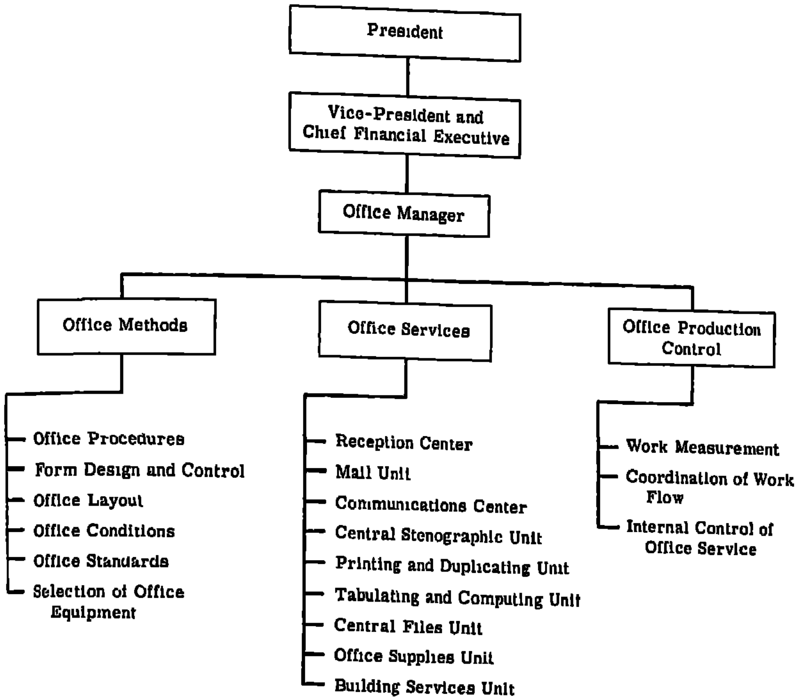


Fig. 30.1. The Office Manager's Organization

department head, the office manager, and the personnel manager is required for a satisfactory solution of office personnel problems. A similar situation exists in the field of office organization planning. The staff function of organizational planning may be placed under the vice-president for administrative staff services, for the administrative echelons of the company; it may be placed under the personnel manager for the operative echelons. The office manager should also be consulted in matters of office organization, provided that he is more than a specialist in office techniques. Some authorities on office management have suggested that the office manager should be given staff responsibility for office costs and budgets. His work should result in the reduction of office costs. His understanding of office activities should enable him to give valuable advice in the formulation of budgets for staff departments. Most manufacturing concerns have a comptroller. This executive has usually the principal staff responsibility for cost and budgetary control. Again the office manager should be consulted. The same situation exists with respect to the purchase of office equipment. Most manufacturing companies

require that all purchase requisitions must pass through and have the approval of the purchasing agent. This includes office equipment. We have commented previously on the principle of compulsory staff advice. A sound application of this principle should enable the office manager to operate effectively in those areas of office management for which he does not have the principal staff responsibility.

An analysis of the qualifications essential for a successful office manager shows that he must have traits similar to those needed by any capable executive. Leadership ability, personality, tact, and sales ability are primary requisites because of the nature of his position. As a staff executive, he receives his authority from a superior line executive. The office manager must have the ability to convince administrative executives of the soundness and feasibility of his ideas and plans. Otherwise they will not be approved and put into practice. He must understand management generally, as well as the principles of office management, if he is to be successful.

It is difficult to assign the office manager a definite place in an organization. His status will depend upon the considerations noted above. The most common location of the office manager appears to be in the financial division. This is probably because of his traditional association with the accounting functions. The scope of the modern office manager's activities may take him into any staff office in any division of the company. Prestige and status sometimes are important factors in getting coöperation. The office manager is located under the chief financial officer, rather than the comptroller in Fig. 30.1, for this reason.

Office Methods, Conditions and Standards

The office manager has a staff responsibility for office methods, standards, and conditions of work that affect the economy of clerical activities. This methods function has several phases:

1. The design of office methods and the development of standard operating procedures
2. The selection of office equipment and its installation
3. The design and control of office forms
4. The development of an efficient office layout
5. The provision of standard office conditions
6. The determination of office performance standards

This work is the chief occupation of one or more employees in a majority of manufacturing concerns. An office of 500 people may employ approxi-

mately 5 persons for such work. An office of 5000 people may employ approximately 15 persons.[5] The larger concern can accomplish as much or more, relatively, with fewer people, because each staff office can carry a larger share of its procedures work. The primary responsibility for the use of good methods falls on the executive who is responsible for the work. The office manager is responsible primarily for giving professional advice and assistance.

The Design of Office Methods

The terms "method," "system," and "procedure" mean approximately the same thing: a relation of steps or subfunctions that is necessary for the completion of some project. An office clerical procedure is designed to facilitate the economical, effective performance of office work. The particular clerical project may be the processing of a standard batch of invoices, the compilation of data for a periodic report, or any other work that employs the time of clerical operatives. The particular kind of project should occur repetitively. It should represent a sufficient work load to justify the time and expense of developing a standard procedure. The steps in the particular procedure should create values that are necessary for the accomplishment of final project objectives. Each step should be designed to make efficient use of clerical labor and equipment. The procedure should be sufficiently flexible to enable it to handle normal variations in work load and conditions of work for the particular kind of project. There are other conditions and requirements of effective business procedure. These were noted in Chapter 5.[6] Many examples of business procedure have been noted in each staff office that has been discussed in previous chapters.

The difficulties that the office manager may experience in his attempts to streamline procedure can be formidable. They are illustrated by a statement that has been called "Parkinson's law": "It is a commonplace observation that work expands so as to fill the time available for its completion. . . . Granted that work (and especially paper work) is thus elastic in its demands on time, it is manifest that there need be little or no relationship between the work to be done and the size of the staff to which it

[5] *Ibid.*, p. 7.

[6] See also R. C. Davis, *The Fundamentals of Top Management*, Harper & Brothers, 1951, p. 744. There are a few good books on business procedure. The Superintendent of Documents, Government Printing Office, can supply some monographs on procedural analysis, at nominal prices. Office equipment manufacturers usually have monographs dealing with those phases of the subject that involve use of their equipment.

Fig. 30.2. A Conference on Forms and Procedures. (Courtesy, Remington-Rand.)

may be assigned. . . . We may distinguish, at the outset, two motive forces. They can be represented for the present purposes by two almost axiomatic statements, thus: I. An official wants to multiply subordinates, not rivals; and II. Officials make work for each other. . . ."[7] The military counterpart of this "law" is the axiom: "Rank is a function of command." There is unfortunately more fact than humor in these statements. The larger the organization, the more these statements tend to have some validity. In these discussions it has been assumed that the office executive is interested in developing economical and efficient operations. This is true in general. It is not the way of the politician, however.

An office procedure should be accepted by the executives who must work under it before it is installed by the office manager. An office executive should have the right to select the methods that are to be used by his department when he is to be held accountable for results. A method will probably fail if it does not have the support of the executives who must use it. A method becomes a standard office procedure when accepted by these executives and approved by higher authority. It is then a technical order; it authorizes the use of the specified methods and equip-

[7] *The Economist*, November 19, 1955, reprinted in *Economic Intelligence*, January 1956, by the U.S. Chamber of Commerce.

ment, under the conditions stated. It may place responsibility for the performance of the indicated steps. It may provide the performance standards that shall be applied. It may convey other information that is required for the proper operation of the procedure. An office manual is largely a compilation of standard procedures, plus additional information concerning the operation of the office. The advantages and disadvantages of such procedures have been discussed previously. It should be remembered that a technical order may authorize the use of methods, but it does not authorize action.

The Selection of Office Equipment

Considerable capital investment in office equipment may be required. Such equipment may be subject to rapid and continuing developments. Its selection is an important responsibility of the office manager. There is considerable choice in the machines and equipment available for office use. The office manager must be familiar with a large variety of equipment of varying degrees of automaticity. The requirement for a professional knowledge and understanding of office equipment is increasing. It is conceivable that the office is on the threshold of a revolution embodying automation, electronic data processing, and high-speed computers. It may cause changes that are very similar to those that were brought about in factory operations by the Industrial Revolution.

The office manager must know when it is more economical to replace manual with machine operations. He must evaluate the advantages of a piece of new equipment. These advantages may be a better quality of office work. Reduction in the time required to process this work may be important. Better utilization of office space may be necessary. Lower clerical costs or other advantages may be the objectives of the proposed equipment purchase. The purchase must conform to the company's policy governing the maximum permissible time for a piece of equipment to pay for itself out of savings. This may be two years or less for some classes of office equipment. The office manager and his procedures specialist must be familiar with many styles and types of adding machines, typewriters, computing devices, tabulating machines, bookkeeping machines, filing equipment, intercommunication systems, and others too numerous to list. He must know the comparative costs, performance, advantages, and disadvantages, of all styles, types, and makes. Most staff executives do not have this knowledge and experience. This is an important reason why the office manager should be consulted before office equipment is purchased.

The Design of Office Forms

Office forms are used to facilitate and control recurrent operations in the office routine. They play an important part in every business office regardless of its size. The major portion of clerical work involves forms in one way or another. The handling and processing of these forms is expensive. The office manager therefore must take great care in their design. Each form should have a definite purpose. It should be designed to accomplish that purpose in the simplest and most effective manner. The collection or transmission of the same information on different forms should be avoided in the interest of economy. Other considerations and rules for form design can be found in any good book on office management.

Office Layout

Office layout and the installation of office equipment are parts of the office manager's problem of standardizing environmental conditions. The proper arrangement of office workers and equipment is as important for efficient clerical output as the arrangement of men and equipment is for production in the shop. The office manager must solve such problems as the proper location of desks and equipment for the most economical utilization of space.[8] The location of phones and internal communications systems and of private and departmental offices must be determined. In planning the most efficient and economical layout for the office, the office manager should follow the straight-line principle for the continuous flow of work. Departments, clerical units, equipment, and desks should be so arranged that papers will be handled easily and quickly, with the least possible moving between the point of their origination and the point of the final closing of action.

Standards of Office Conditions

Standards of office conditions concern the physical environment of the clerical employees. Heating, ventilation, humidity, lighting, noise abatement, and sanitation all present problems with which the office manager must deal.

[8] An office of 100 people might require approximately 150 square feet of floor space per person, or a total of 15,000 square feet. This would include space for executive offices, clerks' desks, file space, reception desk, etc. Some allowance for growth should be made, of course. The annual rental would be $75,000.00 at a cost of $5.00 per square foot per year. The actual cost would depend on the city, the kind and condition of the building, its location, the quality of the space desired, and many other factors. It is evident that some time and money could be spent profitably on a study of space needs and office layout.

The efficiency of clerical workers is directly influenced by the temperature, humidity, and ventilation of the office. Natural ventilation is still the principal means in many offices. The use of air conditioning devices is common in modern offices.

Adequate office illumination is essential to the health and efficiency of clerical workers. Clerks work with their eyes much of the time. In most cases artificial lighting is necessary because the natural illumination is insufficient. The office manager must therefore study the type and kind of artificial lighting that is best suited to the particular kind of clerical work.

Noise presents a problem in most offices. It causes fatigue and nervousness, and distracts attention. This results in personal discomfort to the workers and decreases their efficiency. The increasing use of office machinery increases the noise problem. It may be reduced by sound-absorbing floor, wall, and ceiling coverings, segregation of noisy operations, and other means.

Good working conditions are a factor in high productivity and low labor costs. The installation of such conditions is a phase of the work of organizing for production. This problem was discussed in Chapters 10, 11, and 12, for primary production operations. The development of good office conditions for clerical operations is similar.

Performance Standards

The development of standards for office work is an important part of the office manager's work, for such standards are in general use to some degree in most business offices. Some concerns have adopted the production department's job study techniques, including time and motion study. Standards may be established for typing, filing, duplicating, recording, transcribing, and computing. Group standards of office effectiveness can be developed using the work index method. This will be discussed later in connection with office production control.

Proper performance standards for clerical work have several advantages. Employees can be paid in proportion to production. The efficiency of workers can be measured. The work of the office can be planned, scheduled, and controlled more effectively. The costs of various kinds of work can be reduced.

Office Services

The office manager's organization usually renders certain technical staff services of facilitation. These are functionally different from its

technical staff services of planning and installing clerical procedures. Facilitative services are those that relieve other offices of certain work that is necessary for the performance of their principal functions, but is not an integral part of these functions. Such services are technical in the sense that they are specialized. Their performance does not require any considerable professional knowledge, with certain exceptions that will be noted shortly. These services have to do with the basic office functions of communicating, copying and duplicating, recording and filing, computing, and comparing. The principal office service functions and organizations are:

1. The reception center
2. Correspondence supervision
3. Central stenographic unit
4. Central files
5. Printing and duplicating unit
6. The mail unit
7. The communications center
8. Office supplies clerk
9. Tabulating and computing unit
10. Building services

It will be seen that most of the above service functions have to do with the origination of communications, the act of communicating, or handling the results of communication. The communications may be oral, written, or graphic. The reception center, for example, is a link in the company's system of external oral communications. Salesmen and other callers usually make their appointments or contacts through this center. The first impressions of the company are conditioned by the friendly, courteous, efficient manner in which the receptionist handles these callers. She is a public relations operative from this standpoint. The receptionist is given frequently some routine clerical work, in addition. Her principal duty may not occupy her time fully.

The Origination of Communications

There are certain office services that have to do largely with the origination of communications. Some examples of these are correspondence supervision, central stenographic service, and the printing and duplicating unit.

The technical supervision of the company's correspondence, other than that of the officers and major executives, may be under the office manager. He should be able to advise and make recommendations concerning the design and content of certain form letters, the standardization of the

appearance and style of the letters transcribed by the stenographic staff, and the training of business correspondents. His purpose here is to make the letters as effective as possible at the least cost to the company. Each letter serves as a representative of the company; and if they are to achieve their purpose, they must be written in accordance with proper plans, policies, and directions. The office manager is responsible for periodic analyses of the firm's letters to avoid expensive, superfluous material, and poor appearance, as well as to improve their effectiveness.

The cost of letter writing is subject to inflation, like everything else. The prewar cost of business letters was approximately $0.35 each.[9] A present-day authority says that it is now approximately $1.50 each.[10] Even a small company may originate many thousands of letters annually. This represents a necessary but significant cost of doing business.

There are many things that can be done to reduce the cost and increase the effectiveness of letter writing. Training programs for correspondents can be held. Standard practice instructions may be provided to guide and improve the writing of letters. These may also aid in training correspondents. Form letters are almost indispensable in modern business because of their economy. They may be drawn up for use in recurrent situations. Such letters save the time of both the dictator and the stenographer.

The company's stenographic service may be either centralized or decentralized. A central stenographic unit will be found in many offices under a head stenographer who reports to the office manager. The stenographic work can be planned, scheduled, and controlled more efficiently. The head stenographer assigns requests for stenographic service. She schedules it, and keeps proper records of its progress. Performance standards can be applied more effectively. Salaries can be adjusted more fairly on the basis of individual production. Furthermore, the work is more equally distributed among the stenographers. This increases the output of the staff by avoiding waiting time for some and peak loads for others.

Decentralization of stenographic service usually takes place with organizational growth. It is advantageous, in the case of a highly specialized department whose work is extremely technical. In such a situation, stenographers become more valuable and efficient because of their greater familiarity with the technical terms and requirements of the work. Very large concerns which cover a great amount of floor space may

[9] James F. Grady, *Training for Better Letter Writing*, A.M.A. Bulletin, Office Management Series No. 80, 1937.

[10] C. L. Littlefield and R. L. Peterson, *Modern Office Management*, Prentice-Hall, Inc., 1956.

also find a decentralized system more efficient. The various units of the company may be so widely separated that considerable time is needed for stenographers to go to and from their work. This difficulty can be overcome partially by the use of some modern type of dictating equipment. Its use should be supported by a system that will pick up periodically the disks or other devices on which the correspondence has been recorded for transcription. These devices are moved to the central stenographic section and processed. The finished letters are returned promptly to the correspondent by the same system.

Printing and duplicating services are supplied by the office in the origination of printed matter in large volume. Various devices may be used such as carbon paper, the mimeograph, the multigraph, the ditto process, the automatic typewriter, the ozalid process, and other office blueprinting machines and photocopying equipment. These devices are used for duplicating form sales letters, instruction sheets, bulletins, price quotations, announcements, circulars, and the like. The printing and duplicating unit may operate addressing equipment for imprinting letters, envelopes, or employee names on payrolls. Such equipment may be used for imprinting other records, when lists of names or facts must be reproduced periodically. The principal mission of this unit is the accurate reproduction of communications and records, at low cost with good appearance.

The Handling, Transmission, and Custody of Communications and Records

The origination phase of communication deals with the personnel, equipment, records, and supplies that are necessary to produce a message. The transmission phase is concerned with conveying the written or spoken work from one place to another. This must be done accurately, speedily, and conveniently at low cost. It may be necessary to make and keep a record of communications received or sent. A function of safeguarding other records may be associated with this requirement. The mail unit, the communications center, and the central files unit are concerned with the above phases of the communications problem.

A company's mail unit is concerned with both internal and external mail. Internal mail deals primarily with the transmission of interdepartmental communications. External mail travels through the U.S. mail to or from some destination that is external to our organization. Time is usually an important element in both cases. A well-organized service conserves the time of executives and clerks. It insures greater efficiency in handling the correspondence. Incoming mail must be received, sorted, opened, and

distributed to the proper departments or persons as soon as the office opens. Outgoing mail is collected by messengers periodically during the day, sorted, bagged, and mailed. Interdepartmental mail is picked up at the same time, of course. Efficient mail service requires close coöperation between the company, the post office, railroads, airlines, and steamship companies. The mail service is supervised by the office manager. A unit chief may be in direct charge of this service. The mail unit uses postage meters, automatic letter openers, and other specialized equipment.

The communications center may operate a variety of communications devices. Telephones, both interoffice and outside, are part of standard office equipment for conveying messages. The office manager is responsible for providing efficient telephone service for the company. This requires the proper location of an adequate number of phones. It requires also the efficient operation of a switchboard that will have sufficient incoming and outgoing lines to handle the load.

Other communication devices found in some offices include pneumatic tubes, telecall, teletypewriters, telautograph, messengers, etc. The requirements for speed and capacity vary for different communications problems. The particular company's needs must be studied accordingly.

The office manager has a staff responsibility for the development and use of efficient filing methods throughout the organization. The chief clerk reports to the manager when there is a central files unit. Office files contain information which executives or correspondents often must have before they can dictate certain letters, give information, make reports, or initiate other kinds of communicative action. Improper filing may result in the possible loss of valuable information. It may cause a waste of the executive's time. It may cause the loss of customer good will. Improper filing may produce irritating and costly delays in the routine of management.

The office manager determines the desirability of centralizing or decentralizing the filing system, subject to higher administrative approval. The advantage of centralized filing is greater uniformity of method and the ready availability of material for the entire organization. Decentralized filing, however, makes the material more accessible to the department which uses it. Some office managers have solved the problem by using both: there is a central file for all material that may be used by the entire organization, and a file in each department for the material used only by that department. Thus the engineering department would have its own files. It would probably send certain materials to the central file, however.

The office manager must also decide on the system of filing that will best serve the organization. The most commonly used systems are the alphabetical, the numerical, the geographic, the chronological, and the topical. Combinations of these methods may be used.

The correspondence files of an organization constitute a form of record. They contain much business information that has been classified on some basis. There are many other devices for maintaining and safeguarding records. There are book-type files, card files including decks of tabulating punch cards, visible index files, and many others. The operating records of a staff department are usually a part of its working tools. They are kept in the particular office for this reason. Records that have permanent value but little current value, may be kept in a central storage file unit, rather than in the departmental files. Many concerns microfilm such correspondence and records. Microfilming is a photographic process of recording facts, as the term indicates. It conserves space that would be required for storage files. Microfilm records show little deterioration with time. Such records are highly portable, and conveniently usable. Bulky original records can be destroyed, since the micorfilm copy is legal evidence. Some companies make duplicate microfilm copies of essential records. The duplicates are stored at a distance from the offices in some safe repository. Such storage is a form of insurance against loss from fire or other disaster. There are other problems of record keeping. The office manager must be able to advise other executives concerning them.

Office Supplies

Responsibility for the proper storage and issuance of office supplies also rests with the office manager. A supply clerk is usually in charge of an office supply room. Stationery, forms, carbon paper, clips, pencils, and other supplies sound insignificant. These can represent quite a bill of expense, however. They should be conserved, in consequence. Such supplies should be readily available in adequate quantites when needed, however. The clerk should issue them only when properly requisitioned by a responsible department head. These supplies are charged to the partment's expense account. A departmental desk service may be operated within the department. This service replenishes periodically common desk supplies of low unit value, such as paper clips. The supply clerk should keep some simple inventory record to guard against a shortage of essential items. Such a shortage could interfere seriously with office production. The economic ordering quantities for major supply items, and the corresponding units of disbursement, may be determined by the office manager.

Some controls such as the above are necessary to prevent the waste and misuse of office supplies.

The Tabulating and Computing Center

A large amount of tabulating and computing work is done in many offices. The office manager may be faced again with the problem of the centralization of this work versus its decentralization, in whole or in part. It is desirable to decentralize when no cost savings, or improvements in the speed and accuracy of computations, can be made. There is a tendency to develop computing units or centers when analysis shows that the use of expensive, large-capacity computers is economical. A heavy continuing load of work may be required for the economical use of such equipment. Well-paid, highly trained, skilled operators may be required for their effective use. The individual staff officers may not be able to make efficient use of such labor. The spare time of such operators can be used on ordinary clerical work, of course. The operators must be paid at their skilled rate, nevertheless. The efficient use of computing equipment may require the direction of one or more supervisors who are professionally trained in the field of computing machine operation. The question of the location of the computing center arises when it is decided to set up a computing center. This unit may be placed under the comptroller in some companies. The accounting functions generate a considerable load of computational work. Machine accounting has developed, in consequence. The computing center may be placed under the vice-president for general administrative services, when he has an economic analysis unit in his organization. There are other offices than accounting, economic analysis, or marketing research that have computational problems. It is believed that a computing center should be located under the office manager, if one is to be set up.

A variety of computational equipment can be purchased. This variety suggests the need for specialized training of personnel assigned to the center. Adding and listing machines are found commonly in all kinds of offices. The key-operated electrically driven calculator is a development from the common adding machine. The Comptometer is an example. Such machines are used chiefly for rapid addition and multiplication. There are rotary-type calculators, such as the Marchant and the Monroe calculators. These machines perform quickly and accurately all the basic arithmetic operations: addition, subtraction, multiplication, and division. Accounting machines are specialized calculating devices that can extend, post, add, and total accounting entries on a ledger card. Some of them are com-

binations of calculating machines and the typewriter. Everyone has seen examples of such accounting machines in banking offices. These are used in some manufacturing concerns for inventory control purposes. Electrically operated tabulating and computing machines are found today in many manufacturing offices. The principal manufacturers of such equipment are the International Business Machines Corporation and Remington-Rand. Such machines use punched cards. Electric contacts are made through the punched holes in the cards as they are run through the machine. The electric impulses activate various mechanisms in the machine, causing it to sort, tabulate the data, make computations, and perform other operations of an allied nature. The raw data is punched into specific locations in "fields" on the tabulating card. These locations represent quantities and categories of data. Key punches, sorters, tabulators, computers, and other equipment are required. This is high-speed equipment for volume production of business data. It is used for production control, inventory control, accounting, statistical, and other computational purposes. Electronic computers represent the highest development of computational equipment to date. The principal manufacturers of such equipment are, again, International Business Machines Corporation and Remington-Rand. Other equipment manufacturers are moving rapidly into this area, however. The operation of these machines requires men who are professionally trained specialists. They should understand the theory underlying the design and operation of such equipment. It is not necessary for the average student and executive to have such an understanding. It is sufficient to know that the most complex computations, even those involving higher mathematics, can be broken down ultimately into a sequence of simple unitary additions and subtractions. Linear programming takes the problem and its alternative solutions, and breaks them down into such sequences. The raw data are recorded originally on punched cards, magnetic tape, or punched paper. These devices, when fed into the machine, cause electric charges to be implanted on various electronic tubes. The data are stored electronically on these tubes, in other words. The results of linear programming also can be transferred to tape. This tape, when run through a control unit, causes the storage tubes to release their charges in the proper order and relationship into the computing mechanism. They put the data into the computer in the correct amounts, order, and relationships, in other words. The computer processes these data and computes an answer to the problem. This is recorded by the computer on punched cards or tape. Electronic computers are used in very large offices, such as those of large insurance companies, where there

is a very large continuing load of computational work that must be handled quickly. Such computers are used by the research and development divisions of very large manufacturing concerns. These machines will solve highly complicated mathematical relationships in research problems within a relatively few hours. The same problems might require many thousands of man-hours of work by highly professional personnel, if the same solutions were accomplished with conventional computational devices.

Integrated data processing has received considerable attention from office managers in recent years. This term refers to the integration of a series of clerical, tabulating, and computing operations that are required to process a body of data for some end use. The entire process can be highly automatized. Each step records its results automatically on punched cards or tape. These cards may be used as the means of putting data into the machine for the next step. The final tape may be fed through an electronic computer, if this is necessary. The use of electrically operated tabulating equipment may be sufficient, of course.

Business journals have recorded many instances of amazing reductions in the number of operations and clerks required in many business offices. A fundamental criterion, however, is the time required to pay for the machine, out of cost savings, within a stipulated period time as determined by company policy. This period may be two years or less. The rapid technological progress that is being made with some types of equipment is one reason. The quality, accuracy, and speed of computational work also may be factors in the decision to buy, as noted previously.

There is some danger, when a computing center is established, that various offices may begin to call for reports that are nice to have, but are not strictly necessary. This is more likely when the reports are obtained at no cost to the department head. The increased demand justifies the job of the computing unit chief, furthermore. Consequently some control of computational reports should be established. The cost of reports may be charged back against the expense budget of the department. A committee may be appointed to review all reports, and to recommend elimination of unnecessary reports anywhere in the organization.

These developments in the field of tabulating and computing have set up some additional professional requirements for the office manager. It is not necessary for him to know the technical theories of computing-machine design. That is the manufacturer's problem. It would be helpful if he knew more mathematics than he usually does, however. Many computing machine manufacturers operate schools. The operatives of their

customers are trained at these schools. These manufacturers may supply a machine maintenance service. It is necessary, however, for the office manager to know what computational equipment is available on the market. He should know what can and what cannot be done with it. He should be competent to direct generally the operation of the computing center.

The Control of Office Production

The office manager is responsible for the quantity, quality, time, and expense of office production in the service units that are under his command. He has a staff responsibility for the provision of advice and assistance to other staff executives for the development of an adequate control of their office production. He may be required to operate an interoffice control of production. The fundamentals underlying the control of staff operative production are not different from those underlying line production. The staff phases of control are still routine planning, scheduling, preparation, dispatching, and progress comparison. The line phases are still direction, supervision, and corrective action. The details of a control procedure are different, of course. There are some basic differences between line and staff in the characteristics and requirements of products, processes, and conditions of work. The chain of command of the office executive is a secondary chain. There are other differences. Both office and line production control should be based on standard procedures, however. There should be performance standards for standardized operations. These standards may be set in the office by time study, analysis of office production records, or initially by estimate. Much that has been said about production control in the plant will apply in the office, with appropriate modifications.

The control of production within an office is usually the responsibility of the office head. The control system should be simple. The office head may delegate responsibility for its operation to an assistant. There are various ways in which departmental production can be controlled. The particular office clerical instruments such as requisitions, invoices, or some other kind, can be batched in lots of convenient size when they come into the department. Each batch can be put in a heavy envelope. The standard routing and schedule can be entered on the outside of the envelope. A copy of the route sheet and schedule can be kept at the control desk. A daily report of work from each clerk at each desk should enable us to identify each batch in process, and record its location. This enables the

control clerk to perform the comparison function of progress control. Even this may not be necessary, if we are able to apply the principles of block control that were discussed in Chapter 15. There are other ways of controlling departmental office production of batches or lots of work. They are all examples of operative controls.

The office manager may operate certain administrative controls of office production. Such methods control production by organizational groups, rather than by particular batches of work, or projects. The work index method is an example. The principal clerical instruments that typify the work of the department are determined. The average weekly production of these instruments is determined for a base period. A weekly production index is computed and maintained, using the average production for the base period as 100 percent. A combined production index of all representative instruments is computed. The production index of each instrument is weighted by its total unit process time in the department. A weekly labor index of total clerk hours is computed and maintained for the same base period. The division of the production index by the labor index gives an index of the effective use of the department's clerical labor. A simple example of a graphic presentation of such index numbers is shown in Fig. 30.3. The particular department head may be in trouble unless an increase in work load is anticipated or he can offer some other valid explanation. Another administrative control device involves the establishment of standard float times for the principal clerical instruments that are processed in volume, regularly, in the department. It may be assumed, for example, that 500 pieces of Form A were in the particular office at the beginning of last week. There were 600 pieces in the office at the beginning of the present week. The average number of the forms in process during the past week was approximately 550 pieces. The departmental production records show that 750 completed pieces of this work were shipped from the department during the week. The office works a standard 40-hour week. The average time to get one piece of this form through the office was therefore (550 pcs/750 pcs) $\times$ 40 hr, or 29.3 hours. The standard float time for the form in this department is 3 days, or 24 hours. Float time for most work in this department has been increasing. Again, a satisfactory explanation by the head of this office is in order. The author had occasion to apply this general method of control to a branch of an office that processed large technical reports that varied greatly in size. The average process time was reduced within 2 months from 5 weeks to 10 days. There are other methods for an administrative control of office operations. A budgetary control of departmental expense

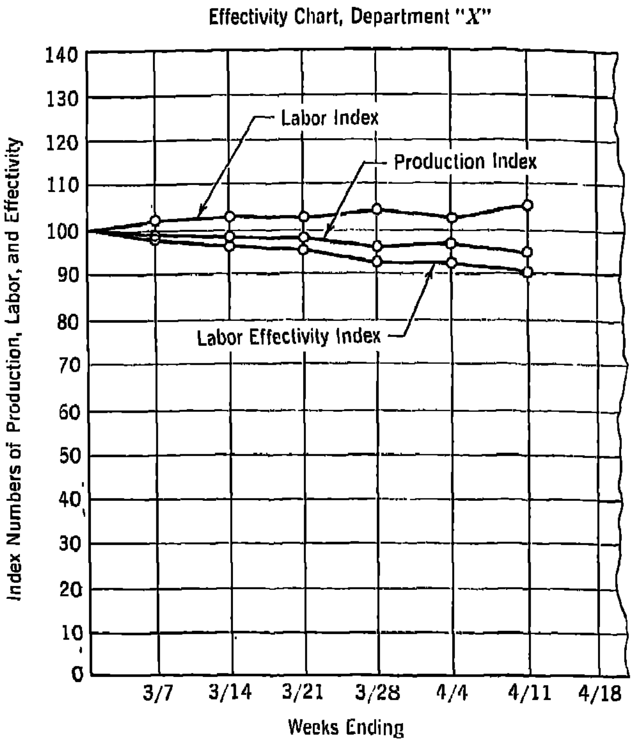


Fig. 30.3. A Departmental Effectivity Chart

is another example. It is the business of the office manager to know these methods.

The Future of Office Management

The necessity and importance of efficient and effective office management have been well realized. There is still a great need for scientific research and improvement, however. Almost as important as new office inventions and developments is the need for men who have been educated and trained for the position of office manager.

There has been an increase in administrative, clerical, and office equipment costs in modern business. The function of office management can contribute much to decreasing these costs. It frequently can improve the quantity, quality, accuracy, and speed of accomplishing office work at the same time. The office manager's job will continue to grow in importance as its values become more generally recognized by operating executives.

PROBLEMS

1. A survey of an office procedure has been completed recently. The methods used in making the survey were similar to those discussed in Chapter 5. The results showed that step #21 in the procedure is important from a cost standpoint. Job analysis questionnaires were filled out previously by each clerk in the department where this step is performed. An examination of these questionnaires has indicated that approximately 3300 clerk-hours per month are spent on step 21 by the department. The weighted average hourly pay rate for the clerks who work on this step is $1.75 per hour. The procedures analyst who made the survey has estimated provisionally that approximately 40% of the clerical labor time that is required for step #21 could be saved by a redesign of the method for performing it. He estimates that approximately 3 weeks will be required to accomplish this saving. The pay rate of a competent procedures analyst on the office manager's staff is $8000.00 per year, or $4.00 per hour. The office in which step #21 is performed works a standard 40-hour week. The company has been making a profit of 10% on sales, before taxes.
   (a) What are the estimated gross savings that are possible through improvement of the step?
   (b) What is the cost of technical assistance by the office manager's department in accomplishing this improvement?
   (c) Should the office manager be held accountable for the accomplishment of the estimated net savings?
   (d) What are the estimated net savings per year?
   (e) What is the annual sales equivalent of these net savings?
2. The office methods section of the office manager's department has recommended the purchase of an expensive piece of office equipment. A study has been made of the savings that could be obtained through the use of this equipment. A conservative estimate of net savings, based on this study, is 25% of the installed cost of the equipment per annum. Net savings are defined in this company as the excess of the total costs of the old method over the new method for the time that the equipment will normally be in operation during the year. The comptroller's department has established a 5-year period of depreciation for this type of equipment, because of the high rate of technical improvement. The trade-in value of the equipment may be neglected, accordingly. A policy has been established that office equipment should pay for itself out of savings within 2 years.
   (a) How long will it take, approximately, to pay for the proposed equipment out of savings? Would you authorize the purchase? Why?
   (b) Are there other considerations, in addition to savings, that might influence your decision. What are they? How would you evaluate their importance, relative to savings?
   (c) Who would authorize the purchase of this equipment in this case? Why?
   (d) Who would purchase it? Why?
3. A work index method of clerical production control has been installed in the

office of the particular company. The record of a certain office has shown the following trends during the past four weeks:

Index	Index Number by Weeks 1	2	3	4
Clerical Labor Force	110	108	109	110
Clerical Production	115	112	113	110

(a) Compute the corresponding labor effectivity number for the weeks indicated.

(b) What could be the causes of such a trend in labor effectivity?

(c) What could the office manager do about such a trend, if anything?

CHAPTER 31 •

• General Administrative Management

Administrative and Operative Management

THE discussion in the previous chapters has dealt chiefly with the field of operative management in industrial establishments. Its purpose has been to examine and relate fundamental objectives, policies, and methods of solving operative management problems, both line and staff. Specific practices have been presented for illustrative purposes only. It has been impossible to avoid some discussion of administrative management for a number of reasons. All major plans and programs must usually have top management approval. Each major operative executive reports directly to a general executive, or comes frequently in contact with general executives, in connection with the development and execution of general plans. It is the responsibility of operative executives, both line and staff, to support their line superiors intelligently and effectively in the accomplishment of the organization's mission. Such executives will not do well for the company, or themselves, if they understand only the problems of operative management in their limited fields of activity. Even minor operative executives should have a practical understanding of administrative management, for reasons that will be apparent shortly.

Management has been defined previously as the function of executive leadership. It is the function of planning, organizing, and controlling the work of others. It has its executive and operative phases. An executive has been defined as one who has substantial personal responsibilities for the direction and supervision of others. Administrative management is that kind which performs management functions for organizational groups. These functions are performed in a manner that will promote the accomplishment of group objectives. Organizational approaches are used for the solution of management problems. Administrative management is group management, in other words. Operative management is that kind which performs management functions for the accomplishment of specific proj-

ects. These projects are specific undertakings, such as the completion of a particular batch, lot, order, or run of work. Operative management is project management, in other words. Such management functions are performed in a manner that will promote the effective, economical accomplishment of project objectives. Operative executives spend most of their time on problems of project control and execution. Even minor operative executives have some problems of administrative management, nevertheless. They must work up their proposed departmental expense budgets for a coming period, in many companies. They must take certain measures to maintain and improve the morale of the departmental organization. They must do other things that relate primarily to improvement of organizational effectiveness, rather than to accomplishment of a particular project. General administrative executives, on the other hand, spend most of their time in planning and organizing the activities of the company, by its divisions and subdivisions, relative to the accomplishment of the company's general objectives. Supervisory executives, at the bottom of the executive ladder, perform operative management functions almost entirely. The president and other general executives, at the top of the executive ladder, perform administrative management functions almost entirely. The requirements of executive jobs shade from those for operative management to those for administrative management, as we climb up the ladder. A brief summary of the relations of general administrative management to operative management may accordingly be in order.

General administrative management has been defined above. It is the work of general executives. Those who are included in the ranks of general executives will vary between concerns. This variance will depend on the size of the company, the extent of decentralization, the point of view of top management, and other considerations. The ranks of general executives may include, in a large corporation, the chairman of the board, the president, the executive vice-president, the headquarters vice-presidents and staff directors, the group vice-presidents, the divisional vice-presidents, and the divisional general managers. It may include a considerable number of assistant vice-presidents and assistant general managers. This sounds like quite an army of top brass. They represent, actually, a small percentage of the total payroll and a smaller percentage of the number of people on the payroll. The number of general executives in a small manufacturing company may be as few as 5. This number may include only the president, the sales manager, the production manager, the treasurer, and an executive assistant to the president. The meaning of the term "top management" also varies between companies. It includes here

those heads of the company's organic divisions, production, distribution, and finance, who report directly to the executive vice-president or the president. It should include those heads of major staff divisions of the organization who also report to these top executives. The principal management functions of general executives have been noted previously. These are administrative planning, administrative organizing, administrative controlling, or some executive phases of these functions. These executives use chiefly organizational approaches to the solution of business problems. This is necessary to enable top leadership to hold subordinate leadership accountable for planned results. The establishment of such accountability gives greater assurance that departmental, plant, and divisional results will build up into a satisfactory accomplishment of company objectives.

Administrative Planning

All executives spend some time in planning. Supervisory executives, on the first level of managerial service, spend most of their time in controlling the operative execution of plans, nevertheless. Top executives spend a large proportion of their time in general administrative planning. This function may be defined as the work of determining bases of action for the organization as a whole, and its principal divisions. General administrative planning in large organizations includes usually the work of determining such bases down to the plant level. Group and divisional planning may be decentralized to the corresponding offices. It is the plant manager's responsibility to see that the necessary administrative planning is done for the plant organization, the plant divisions, and their departments. Much of the planning at the plant level is likely to be operative, however. The department is usually the lowest organizational component for which any substantial amount of administrative planning is done.

The Objectives and Scope of Administrative Planning

The purpose of general administrative planning is a statement of organizational objectives and the requirements for a satisfactory accomplishment of them. This statement should supply a basis for group coöperation and coördination, leading to an economical and effective accomplishment of these objectives. The requirements for effective administrative plans and planning are basically the same as those for any plans anywhere. These requirements have been discussed previously. General administrative plans must be sufficiently specific to supply a basis

for coördinated action. They should not be detailed, for a number of reasons. Detailed specifications tend to be restrictive. General executives cannot be familar with operating details at the plant and departmental levels unless the plant is very small. Execution takes place at the latter levels, however. Business forecasting is far from an exact science. This difficulty alone is sufficient to bar detailed plant planning by headquarters corporate offices. The necessary adjustments to meet changing conditions can best be made at the plant level. Top management is responsible for the determination of general objectives that will keep the company competitive, as well as profitable. It must know the general requirements for their accomplishment. These objectives include specific sales volumes, in dollar and physical amounts, by product line, plant, territories, and time periods. Sales objectives are determined in part by the objective that is set for the company's competitive position at the end of each time period. This decision is conditioned by the results of marketing research and engineering research and development. The company's general executives must determine its profit and expense objectives, relative to forecast sales for the above periods. All the previous objectives depend on the accomplishment of quality objectives, in the long run. The determination of such objectives requires the projection of the additional product values that should be offered to customers, at the same or lower real prices, to maintain or improve the competitive position of particular product lines. The initial determination of quality objectives requires close coöperation between the marketing and engineering divisions. The specific recommendation will come probably to a product committee from the office of the director or vice-president for engineering services. These recommendations may require the approval of the president and the concurrence of an executive committee of the board of directors. The general approach to new product development was discussed in connection with the work of the marketing and engineering divisions.

The above objectives are related to one another. A number of different general plans for their accomplishment must be drawn, nevertheless. There should be, for example, general marketing plans. These may state sales objectives for the next 5 years, and each intervening year. These plans should state generally the action that the marketing division proposes to take for the accomplishment of these objectives, and why. It is probable that there will be also general plans for the expansion of plant and equipment to handle projected increases in sales volume. General plans for organizational development and expansion, general plans for decentralized operations, general executive development plans, general

financial plans, and others will be necessary. The development of general financial plans was discussed in connection with financial management. It was noted then that the development of financial plans must wait on the plans for the operations that are to be financed. This financing may use internal sources of funds, such as depreciation reserves and retained earnings. It may use external sources of funds such as the sale of shares of stock and the sale of bonds or other evidences of indebtedness to creditors. Some combination of these sources may be used. The source of funds and method of financing will depend obviously on the projected development and growth of the business. Financial planning is not least, however, because it tends to come last in the parade of general administrative plans.

It has been noted, in previous discussions of plans, that the time span governs the character of plans, as well as the extent to which they can go into detail. Business plans can be classified, on the basis of time spans, as long-range, intermediate, and short-range. The long-range objectives of a growth company are the logical starting points for general administrative planning. These objectives are related closely to the ultimate service objectives of the company. Long-range plans are based largely on the secular trend of the company's business. Such plans usually cover a time span of 5 years or more. Intermediate plans cover usually a period from 1 to 5 years. Their development tends to be affected by the company's position in the business cycle. It is difficult to determine this position with satisfactory accuracy. Short-range plans have a time span of 1 year, or less. The development of such plans is affected by normal seasonal variations in sales and other business factors. Plans for 1963 are long-range projections in 1958, but short-range plans in 1962. General administrative management is interested in the short-range administrative plans. These show what action is contemplated by major organizational groups during the coming year. These also indicate what progress in the execution of longer-range plans is probable.

Policies for Administrative Planning

There are certain policies that should be followed in general administrative planning. The following examples will illustrate their nature.

1. A general administrative plan is not sacred because it has been developed under the immediate direction of the company's top executives. Any plan can be changed at once if the facts warrant the change. No change in general administrative plans can be made by subordinate executives, except on the basis of approved recommendations that have been submitted to higher

authority, through channels. Subordinate executives must develop their detailed plans within the framework of the company's general administrative plans.

2. Operations should be decentralized on a profit-center basis. A profit center is a manufacturing facility that can be implemented economically with men, equipment, money, and leadership for the accomplishment of an assigned mission. This mission is the complete job of producing and distributing one or more assigned product lines, at a profit. Complete profit responsibility should be established for the executive in command of the profit center.
3. Company objectives should be determined on a profit-center basis. A division or a plant may be a profit center. It is possible to use a major subdivision of a plant as a profit center, when it can meet the requirement indicated in (2), above.
4. The maintenance and improvement of the competitive position of each assigned product line should be required.
5. General administrative planning should be done on a profit-center basis. This includes long-range planning for product-line development. Detailed planning should be decentralized completely to the profit center.
6. All forecasts and plans should be reviewed and modified at least annually. The principle of rolling forecasts and overlapping plans should be applied. These principles have been noted previously.

The company may have developed a manual for administrative planning by its headquarters, divisional, and plant offices. These and other policies will probably be stated in this manual.

Administrative Planning Methods

The procedure for general administrative planning will be stated in the planning manual. The details of procedure also will vary between companies. The complexity of the procedure is indicated by the amount of time that is spent on the development of general administrative plans. Important general executives spend many months of the year in conferences and other activities that have to do with plans development. A glance at any timetable for the submission of administrative plans by company divisions will confirm this statement. The necessity for coördinating short-range and intermediate plans with long-range plans is an important reason for this time requirement. These details cannot be discussed, since this book deals primarily with operative management. The general method of approach can be stated, however.

1. Sales, expense, and profit objectives are established provisionally for each division or plant of the company. These objectives should be established by product lines for each year in the time span that is covered by long-range planning. These objectives and their general requirements are developed by the company's headquarters staff. The proposed objectives for each

profit center are submitted to the responsible executive in charge of each profit center for his consideration.

2. A schedule for the submission of various kinds of plans to the headquarters planning group or office is set up. The first to be submitted may be the profit center's counter proposal of objectives, and the last may be its proposed budget plans.
3. Each profit center develops its general plans for accomplishing its assigned objectives. It submits these plans to company headquarters, in accordance with the planning schedule.
4. Conferences are held between profit-center and headquarters executives, leading possibly to a modification of proposed profit-center objectives and plans.
5. The plans of the various profit centers are consolidated into an integrated plan for company growth.
6. The integrated plan, together with its financial requirements, is submitted to top management and the board of directors for approval.
7. Detailed operative planning is begun by divisional and plant personnel, on the basis of approved administrative plans for the particular profit center.
8. The work of organizing for the execution of these plans is accomplished.
9. The execution of plans is commenced at the plant level.
10. Headquarters and profit-center offices apply an administrative control of progress in the execution of plans.

The application of the above general method may be illustrated by a simple example. The provisional determination of the asset objectives for profit center X of Company M will be used. It is assumed that the forecast period is 5 years. Forecasts and plans will be made for the fifth year and each intervening year. This example will be concerned only with the asset objectives for the fifth year. These objectives should be expressed in "constant" dollars to avoid the distortion caused by inflation.

1. The projected sales for the industry, at the end of the fifth year are .... $1000 million
2. An objective of improving the company's competitive position from 15 to 20 percent of total industry sales has been set for the 5-year period 20%
3. An objective of total company sales, at the end of the 5-year period has been set, accordingly, at $200 million
4. The sales objective for profit center X is set at .... $60 million
   This profit center produces and sells product line Y. This product line accounts normally for 22 percent of our total sales. It is forecast that this proportion will increase to 30 percent by the end of the 5-year period.
5. Provisional profit objectives are formulated for profit center X. These objectives are based on previous company and profit-center performance, as compared with that of its principal competitors.
   a. Company policy governing required profit on net assets before taxes 20%

b. The objective for profit on sales for the particular product line, at the end of 5 years 12%

6. The approximate capital turnover objective for the particular profit center is, accordingly.. 1.67 turns
The duPont formula says that $P_e = T_e \times P_s$, in which P_e is the rate of profit on total tangible assets, T_e is the capital turnover rate, and P_s is the rate of profit on sales. Then, $T_e = 20/12$, or 1.67 turns per year, by the end of the 5-year period.

7. The maximum tangible assets that can be employed by the profit center by the end of the 5-year period is........................ $35.928 million
T_e=(Total net sales)/(Total tangible assets). Total tangible assets=(60 million)/1.67 turns, or $35.928 million. This figure can be broken down by classes of assets, of course.

8. The same general approach is applied to all other major performance factors, as well as total tangible assets, for each year of the 5-year planning period.

Such provisional figures, as the above, merely furnish a basis for further discussion. They are obviously no substitute for executive judgment and experience. The vice-president for general administrative staff services, or the profit center's personnel director, may object that the proposed rate of expansion is unrealistic. They may question that the required complement of administrative and major operative executives can be made available to the particular profit center by the end of the forecast period. It may be necessary to step up the executive development program. It may be necessary to buy some executive leadership from outside sources. Profit-center executives may object to the asset limit of $35,928,000, or some phases of it. They may feel that it is a projection of past production history that does not account sufficiently for the effects of automation. The profit center's marketing executives may feel that the strength of their competition and anticipated marketing conditions make it most unlikely that an improvement in competitive position from 15 percent to 20 percent of total industry sales can be accomplished within 5 years. Other objections to these provisional estimates probably will be raised by profit-center executives. There is always some danger of friction if profit-center executives feel that the headquarters staff is merely a group of high-priced, unrealistic statisticians. The headquarters group, on the other hand, may feel that profit-center executives are trying to put unnecessary "fat" into the estimates, to make their missions easier for themselves. The resulting conferences must lead to a compromise that will be accepted and supported by everyone. This compromise must be accomplished within a reasonable period of time, furthermore. Otherwise the president may be required to make a decision. Time is always a limiting factor in the ac-

complishment of any objective. The above case is an oversimplified example, obviously. It shows at least why general executives spend much of their time in administrative planning.

The administrative plans of each profit center should be supported by programs of major projects that are expected to lead to accomplishment of the objectives of these plans. These programs should be correlated with the requirements of the duPont formula, if it is to be used for administrative planning and control purposes.

Programs for the Support of Administrative Plans

Most supporting programs will fall in the following categories: (1) those that improve organizational effectiveness, (2) those that improve the profit center's competitive position, and (3) those that improve its profit margins. Projects that improve organizational effectiveness include that for the development of better executive leadership. There are others that we have seen previously. Projects that improve competitive effectiveness include those for product improvement and new product development. Such projects include proposed sales expansions into new territories and many others. There are many kinds of projects that can contribute to the improvement of profit margins. It may be possible, for example, to develop unique product attributes in a particular product that will permit a larger profit margin on sales. Capital turnover can be improved by the development of better production control and better inventory control. Expense reduction programs, such as those involving work simplification, will contribute directly to improved profits. These and other kinds of projects, in all three categories, have been discussed in earlier chapters of this book. It is the responsibility of the profit center to decide what programs and projects will lead to accomplishment of assigned objectives. The plant programs are reported to divisional headquarters, in one large corporation, together with the justifications of increased budget requests and proposed organizational expansions. The divisional headquarters consolidates its plant programs, and forwards the consolidated programs to company headquarters. The general progress of the plants in the execution of their programs is checked by divisional headquarters periodically. They check also the extent to which results are adding up to an accomplishment of project and program objectives. Financial and nonfinancial summaries of results are forwarded to company headquarters. The plant management is responsible, however, for the operative planning and controlling of its projects. The completed developmental projects must be welded into the daily and weekly processing of sales and production schedules

and orders. The problem becomes one of operative management when this happens.

The problem of administrative planning has been discussed in terms of a large growth corporation. The term "growth company" should be defined. It is one which is improving its competitive position steadily while maintaining or improving its rate of profit on the capital that it employs. A long record of increased sales at a loss is not regarded usually as characteristic of a growth company. It should be noted also that there is nothing in the above discussion of administrative planning that cannot be adapted to the needs of the small manufacturing company. The pattern must be cut to size, of course.

The Organization for Administrative Planning

There must be some organization for staff administrative planning. The problem is too complicated for personal direction and supervision by top executives, supported by cross-coördination between executives on lower echelons. Such cross-coördination is most helpful, of course. Much of the planning is done by technical staff offices at the headquarters, divisional, and plant levels. There may be a planning committee at a major organizational level. Its membership includes the principal executives at that level. Its purpose is to accomplish a meeting of minds concerning various administrative plans. The vice-president for general administrative staff services, in Fig. 6.1, may have the staff responsibility for coördinating plans development. He coördinates thought. He does not do the thinking for subordinate groups who have the immediate responsibility for plans development. He may provide, later, a staff administrative control when plans are being executed. The counterpart of this vice-president, in the small company, may be the assistant to the president.

Administrative Organizing

Organizing is a basic management function. It is the work of creating or providing those basic conditions that underlie planned programs and projects, and are necessary for their successful completion. These are the conditions that should be present before execution of the plan is started. It may not be necessary to supply certain underlying conditions until the particular phase of the plant to which these relate is about to start. The organizing phase of administrative management has to do with supplying the basic factors and conditions to an organization that will enable it to accomplish its general objectives. The principal factors usually are lead-

ership, equipment, personnel, and money. The head of a division or a plant can be held accountable for specified results when he has been provided with these factors or is able to acquire them. He should be given, of course, an established position of leadership. This position should be clothed adequately with responsibility and authority that has been published in the organization. The general nature and requirements of the organizing function have been discussed previously.

Administrative Control

Control is another organic management function. It has to do with the constraint and regulation of action. Its objective is assurance of the accomplishment of planned objectives with maximum economy and effectiveness, in so far as this depends on well-coördinated action. Operative control has been discussed in connection with production control, quality control, and other control functions. Administrative control is concerned with the coördination of group action in the accomplishment of organizational objectives over a period of time. The 8 basic control functions apply both to administrative control and operative control. This should be evident, since the reports of operative control, concerning project results, are the returns for administrative control, when these results have been summarized by organizational components. A discussion of administrative control methods must be left to books on administrative management.[1]

This book has taken the reader from the floor of the shop to the president's office. The execution of the company's administrative and operative plans takes him back again to the operative's job in the shop, and the salesman's job in the field. It takes the reader back, therefore, to the beginning of this book.

PROBLEMS

1. An example of a preliminary determination of the 5-year asset objective for profit center X of Company M, was given on page 906. The capital-turnover objective was 1.67 turns per year. The largest and most successful competitor of the company has a capital turnover rate of approximately 2.0 turns per year.
   (a) What would be the rate of profit on total tangible assets if Company M were able to achieve a turnover of 2.0 turns per year? Assume that the objective of 12% on sales, before taxes, will be achieved.
   (b) What are some of the things that can be done to improve the rate of turnover of total tangible assets?

[1] See R. C. Davis, *The Fundamentals of Top Management*, Harper & Brothers, 1951, Chapters 17, 18, 19.

(c) What is required in the way of staff operative planning at profit center X to improve such captial turnover?
(d) What is the relation between such planning at profit center X and administrative planning at the general offices of Company M?
(e) What contributions can be made to such operative planning at profit center X by headquarters technical staff executives in the general offices of Company M?
(f) The improvement of profit margins and competitive positions are the immediate responsibilities of divisional and plant executives, under a product-line, profit-center form of decentralization. What coördination of action can or should be exercised by a headquarters administrative control group in connection with an improvement of the rate of profit on net tangible assets?

2. The total sales of the industry in which product line Y falls were $570.884 million during the past year. The company's share of this market was approximately 8.0%. It is intended to improve this position to 8.4% at the end of the first year of the period. The objective at the end of the fifth year is a 10% competitive position. The sales of the industry are increasing at the rate of 1.0% per year approximately. The present rate of profit on sales is 10%. The objective at the end of the first year is 10.4%. This objective is necessary to assure the accomplishment of the objective of 12% on sales at the end of the fifth year. The present rate of profit on total tangible assets is 15%. A 16% rate has been set as the objective for the end of the first year, and 20% for the end of the fifth year of the period. The present total tangible assets is $30.447 million. The asset objective at the end of the first year is $31.369 million.

One year has passed. The annual report of profit center X for product line Y shows the following results: total net sales for the year, $47,550,000; total tangible assets, $31,500,000; total net profit before taxes, $4,950,000.
(a) What is the rate of profit on net sales, before taxes, at the end of the first year of the period?
(b) What is the rate of profit on total tangible assets?
(c) What is the capital turnover rate? What should be the total tangible assets?
(d) What is the competitive position at the end of the first year, assuming that industry sales increased normally?
(e) What other administrative comparisons of performance could be set up for profit center X?
(f) What corrective action can be taken by the top management of Company M to improve the performance of profit center X?
(g) Should we check progress in accomplishing long-range plans more frequently than annually?

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• Glossary of Terms

Accountability: A requirement or condition under which each member of the organization renders a report on his discharge of his responsibilities, and is judged on the basis of his record of accomplishments. Responsibility, authority, and accountability are individual rather than group problems.

Administration: A term that is synonomous with administrative management. It is used by some writers to include both operative and administrative management. It is not so used in this text.

Allowances, Time-Study: The time added to the base cycle time for an operation to assure that the operative will be able to produce continuously, for an indefinite period, at the standard rate of performance, without detriment to his health or well being otherwise. The usual allowances are for fatigue and necessary delays.

Appeasement: A sacrifice of sound objectives and principles to expediency. It is unmoral, unsound, and usually leads to failure. It is the antithesis of compromise.

Attachments, Auxiliary Machine: Devices for adapting the mechanical functions of a machine to the requirements of an operation on the material or product.

Authority, Managerial: The right to plan, organize, and control the activities of the organization for which the executive is responsible. It consists principally of the rights of decision and command, for this reason. Authority, whether managerial or operative, is a derivative of responsibility.

Authority, Operative: The right of the operative employee to make operative decisions concerning the performance of a specific work assignment, within whatever limits are established by his supervisor.

Authority, Staff: Certain rights of decision concerning the staff services rendered to the line or other staff organizations, but without rights of command. The staff executive has both rights of decision and command within his own staff organization, however.

Automation: That field of knowledge which deals with the automatic handling, processing, gauging, and movement of materials between operations on a product or component part. It deals with an advanced form of mechanization.

Balance-of-Stores Record: Another name for a "perpetual" inventory record. It may be called, in some concerns, a stores ledger, a stock record, or by some similar name.

Balance, Organizational: A condition in which the relative development of the functions of an organization conform as closely as practicable with the importance of their contributions to an accomplishment of the organization's objectives.

Base Rate of Pay: A rate which tends to approximate the going rate of pay in the community or the industry for people who are basically qualified for the particular class of work. It is frequently the starting rate of a new employee.

Block Control: A hybrid form of production control that is intermediate between order control and flow control of production.

Board of Directors: See *Committee.*

"Bottom Management": The term is largely synonomous with minor operative management, supervisory management, or departmental management.

"Brain-Storming: A popular, nontechnical term for certain techniques for the stimulation of creative thinking in the development of new ideas.

Break-Even Chart: A graphic method for expressing expense factors in a manner that will show their effects on profits with changes in business volume.

Budgeting: The work of planning and controlling the expenses that are required for the accomplishment of predetermined sales and profit objectives. It is a staff function.

Capacity for Growth, Organizational: The ability of an organization to adjust, continuously, its structure, facilities, and personnel to permanent changes in business volume, without serious loss of economy or effectiveness.

Capacity, Machine: A measure of the maximum production that can be expected within a specified time period from a machine or group of machines in a particular classification. Machine capacity is usually expressed in terms of machine hours, for production control purposes.

Capacity, Plant: A measure of the maximum production of a plant that it can reasonably be expected to produce consistently over a time period. This capacity may be expressed in tonnage or other physical units, in constant dollars, total machine hours by major classes of equipment, or some other appropriate and practicable unit.

Capital, Aggregation of: A term used to indicate the tendency of business operations to require increasing amounts of capital with increasing mechanization and business growth.

Chart, Procedural Flow: A device for summarizing in graphic form the principal facts and functional relationships in a procedure. It may also be called a "routine" or "systems" chart.

Collective Bargaining: A process by which an agreement is reached between the representatives of the owners and the representatives of the employees of a business, concerning the compensation and conditions governing the purchase and sale of the employees' services.

Committee: The committee is a type of staff organizational element. It is a group of individuals who meet for the purpose of effecting an integration of

ideas, leading to a meeting of minds, concerning a solution for some problem. The Board of Directors is not a committee of the business organization. It is a group of elected representatives of owners of the business.

Comparison: That function of evaluating completed performance for each critical step or phase of a project, or for the particular undertaking as a whole. It determines the degree of agreement between actual and planned performance as a basis for corrective action.

Compromise: A modification or choice of methods, without sacrifice of proper objectives or sound principles, to accommodate the beliefs or desires of organization groups or individuals.

Comptroller: The principal staff executive in the field of Finance. He is immediately responsible for the accounting functions, and such related functions as may be assigned to him.

Contract, Purchase: A legal statement of the obligations created by agreement between vendor and vendee for the exchange of certain values and the conditions governing the discharge of these obligations.

Control, Administrative: The control of action by individuals and groups in the completion of programs for the accomplishment of organizational objectives. It is group control.

Control, Concurrent: Those functions that seek to establish control of action after that action commences. Concurrent Control includes Direction, Supervision, Comparison, and Corrective Action.

Control, Decentralized: Control is decentralized in some degree when the responsible executive has assigned some or all of the work of controlling a particular action to a subordinate executive who is closer to the point of performance. Increasing decentralization of control results in an increasing separation of administrative control from operative control.

Control, Operative: The control of action by individuals and groups who are performing the steps or operations that have been prescribed for the execution of a specific project or undertaking. It is project control.

Control, Preliminary: Those functions that seek to establish control of an action before that action commences. Preliminary Control includes Routine Planning, Scheduling, Preparation, and Dispatching.

Control, Production: That control function which has to do with the coördination of manufacturing operations in the execution of product plans and production programs.

Control, Span of: See *Supervision, Units of.*

Controlling: The work of constraining, regulating, coördinating and adjusting the activities of the organization in accordance with the requirements of the plans for the achievement of specified objectives.

Controlling Accounts, Inventory: Summary Accounts in the Company's general ledger that are set up by the accounting department for the items or accounts in a given classification of materials. The individual store's ledger accounts are closed into the controlling account for the particular classification.

Coördination: The development and maintenance of a proper relation of activities, either mental or physical. The coördination of thought is an important

function in the joint development of plans. The coördination of action is an important function in the control of execution. Such coördination involves two principal considerations: time, and the order of performance of the principal activities.

Corrective Action: That function of control which is concerned with correcting deviations from planned performance, when they exceed normal limits of variation.

Cybernetics: That field of knowledge which deals with the science of communications for the purposes of control.

"Dead" Time: That part of total float or lead time for a part or assembly which is not directly productive. It includes the time during which work is moving between operations, waiting at a machine for the next operation, moving to or waiting for inspection, moving between departments, etc.

Decentralzation: A process whereby some higher central source of responsibility and authority assigns certain functions and duties to subordinate positions. It is accomplished through delegation.

Delay Study, Ratio: A statistical technique for determining the frequency of each kind of delay for a class of work or machine. It is based on the statistical theory of sampling.

Delegation, Executive: A process whereby certain of the executive's functions, responsibilities, and authorities are released and committed to designated subordinate positions. The direction of delegation is always downward in business organizations.

Democratic Process: A political process whereby a democratic society governs itself. Some business writers have applied the term erroneously to processes for the application of the principle of participation. The term can not be applied properly to the management of economic or other nonpolitical organizations.

Deviation Factor: A time-study term that refers to the ratio of the average retained time for an element or operation to the minimum or best retained time.

Devolution, Functional: The differentiation and downward growth of a hierarchy of functions from some larger function. It leads to the development of operative specialization. The devolution from an organic business function leads to primary operative specialization, except in the case of Finance. The devolution from a major staff function leads to secondary operative specialization.

Dies: A kind of tool used by certain types of machines that apply force to materials, causing it to take a shape that is determined by the form of the die. Such operations as piercing, stamping, drawing, forming, bending, forging, and extruding, use dies.

Direction: That function of control which supplies instructions concerning the nature and requirements for a proper execution of a plan.

Dispatching: That function of control whch assures proper time coördination by means of a controlled release of authorty to act.

Echelon: A level of service within an organization.

Education, Industrial: Any process of developing an understanding of some organized body of knowledge that explains the work of the industrial organization, or some phase of it, and its performance. This work may be executve or operative, line or staff, mental or manual.

Employment: The work of selecting, hiring, transferring, promoting and releasing employees in an organization or some component of it. The staff function of employment is a phase of the work of the personnel division.

Employment Program: The labor requirements program, adjusted for present man-power, labor turnover, productive efficiency, training requirements, or other considerations.

Engineering Function: An applied physical science. It seeks to apply the physical forces of nature to the uses of man. The engineering function in manufacturing establishments is concerned chiefly with technical research, product engineering, and process or methods engineering.

Ethics, Business: That field of moral philosophy that deals with questions of "right" and "wrong" in the conduct of business activities.

Evolution, Functional: The differentiation and outward growth of a staff function from the chain of command to which it is attached, and the development of staff components.

Executive, Business: A business executive may be anyone who leads a business organization or some component of it. The term includes any employee who has personal responsibility for directing and supervising the work of others, provided that the particular leadership responsibility constitutes his principal assignment.

Executive Development Programs: Programs for the self-development of promising candidates for general executive responsibilities.

Factor, A Business: Anything that affects significantly the performance of business functions, and therefore the accomplishment of business objectives.

Factors, Physical: Any physical implementation of the performance of business functions. Such implementation is the contribution of capital to business economy and effectiveness. The term includes, in the manufacturing business, such factors as the plant site, buildings, equipment, tooling, inventories, and other facilities.

"Feed-back": The communication of information concerning the status of performance to an individual or instrument that must take corrective action.

"Fifo": An accounting term that is used in connection with a value control of inventories. It means "first-in-first-out."

Financial Analysis: The function of evaluating financial data, for the purpose of assisting management in planning, organizing, and controlling the activities of the business. It is a staff function that is usually performed at the level of general administrative management.

Financial Management: The work of planning, organizing, and controlling the provision and use of the company's capital within the limits of delegated responsibility and authority.

Financial Ratios: Mathematical expressions of significant relationships between certain items in our financial statements or books of account. These

items represent usually basic factors, forces, or effects in the conduct of the company's business.

Fixture, A: A device that is fixed rigidly to the bed or table of a machine for the purpose of holding a piece of work in proper position for processing by a tool in the machine.

Float: The amount of inventory of a material part or product that is in stores and/or production between two points in its processing.

Flow Control: A type of production control that is based on the maintenance of a predetermined rate of flow of work from each machine or work center that is used for the production of a part or the assembly of a product. It is found commonly in plants engaged in continuous manufacturing.

Flexibility, Organizational: That quality of an organization that enables it to adjust itself to temporary changes in business conditions, without serious loss of economy or effectiveness.

Forecasting, Business: The prediction of business phenomena during some future time periods. It may be concerned with general economic, industry, and company sales and related business conditions.

Forecasting, Sales: The prediction of the physical and dollar volume of sales for a coming time period. It is done usually by product classes, price lines, and territories.

"Fringe" Benefits: These may include any values that the employee receives in addition to direct compensation for services rendered, such as retirement benefits, paid vacations, and other benefits.

Function, A Business: Any distinct phase of the work of an organization that can be distinguished and separated, if necessary, from other phases of the work.

Function, Ultimate Unit: A single, simple act of operative performance either mental or physical that has definite points of startng and stopping. It is a unit motion in the case of manual performance.

Functional Differentiation: The process of separating functions for the purpose of regrouping them in assignable work units, either general or specific. It tends to take place with an increase in the volume of business that a company must handle.

Functional Integration: The reverse of the process of functional differentiation. It tends to take place with a decline in the volume of a company's business.

Functions, Complementary: Those that are related to one another through successive contributions and a build-up of values leading to an accomplishment of the final or end objective of a particular project. The development of any business procedure requires a relation of complementary functions, together with physical factors and personnel for their performance.

Functions, Coördinative Staff: Those whose purpose is primarily to assist line executives and their organizations in performing the function of control, or to perform some facilitative service that is associated closely with the coördination of action.

Functions, Managerial: The work of executive leadership. It involves basically the work of planning, organizing, and controlling the activities of others.

Functions, Operative: Any work that does not involve substantially the direction and supervision of others. The performance of primary operative functions results directly and immediately in the creation or distribution of salable values. The performance of secondary or staff operative functions serves collateral or secondary objectives.

Functions, Organic Business: Those basic functions whose performance is so vital that business activity within the organization will cease unless they are performed somehow, somewhere, by some one, at some time, in the minimum degree that is required for a satisfactory accomplishment of primary objectives. All line and staff functions devolve from them with growth. Such organic functions have to do primarily with the creation of utilities in our goods or services, the distribution of these utilities and the provision of capital.

Functions, Similar: Similar functions are those that have like objectives and work characteristics; that, in consequence, give rise to similar problems involving similar factors, forces and effects; that require similar background, training, experience, intelligence, and personality in the personnel assigned for their performance. The development of organization structure involves the grouping together of similar functions.

Functions, Staff: Work that has been differentiated from a line hierarchy of functions, at some level, to render some service to the line organization or some other staff group. The principal staff functions are investigation, analysis, interpretation, recommendation including plans formulation, coördination including assistance in control, and facilitation.

Functions, Technical Staff: Those whose purpose is primarily to assist line executives and their organizations in performing the function of creative planning, or to supply some service of technical facilitation.

Gauges: Devices for determining the degree of quality that has been produced in a product or component part.

Grievance Procedure: A formal method for handling employee dissatisfactions, resulting from some conflict of interests, either personal or organizational. The objective in setting up such a procedure is greater assurance that such conflicts will be resolved amicably, justly, and quickly.

Guaranteed Wage Plans: Any of a number of plans for stabilizing employee purchasing power by assuring some continuation of wage payments during unemployment over some period of time. This may be accomplished by regularizing employment, regularizing employee earnings, the provision of reserves for the payment of supplementary unemployment compensation, or by some combination of methods.

Ideals, Business: Moral values that are acquired through the ethical conduct of business. They are the basis of business confidence and good business relations.

Incentive Rate of Pay: The percentage rate above base pay that should be earned by the average employee, who has been properly selected and trained for his work, when he meets a fair standard of performance.

Indoctrination: Any process of inculcating some doctrine or philosophy in the minds of individuals or groups with a view to gaining some degree of under-

standing and acceptance. Its objective is a conditioning of thought and action in the area of the doctrine. Complete indoctrination is impossible in and incompatible with a free enterprise economy.

Industrial Revolution, The: A term commonly used to designate a twenty-year period, from 1765 to 1785, approximately, during which certain fundamental changes and conditions of manufacture took place in the English Textile Industry. The changes were revolutionary. The social and economic forces generated by them have never ceased to operate.

Industries, Assembly Type: Those in which a number of component parts are united by mechanical means to make a finished product.

Industries, Process Type: Those in which one or a very few raw materials come together in or near the initial operation. These travel together, often in a state of chemical union, until the product is completed. All products go through the same general stages of the basic process.

Inspection: A function of quality control that makes a technical comparison between the actual quality of the product and the applicable quality standards to determine whether the quality that has been produced is acceptable.

Instructions, Standard Practice: A standard practice instruction is a written description of what is regarded, at the moment, as the best method of executing a kind or type of project. Another term is standard office procedure, or standard office practice.

Interview Methods: Any technique for obtaining facts from one individual or a very few individuals by some questioning procedure. It may supply facts to the person interviewed. An employment interview, for example, seeks to obtain facts from an applicant that will assist in determining his qualifications for a particular job.

Inventories, Manufacturing: The quantity of materials or supplies, by individual items or classes of materials, that are in stores or in process between any two points in the flow of production.

Inventory Control: The staff function of constraining, coördinating, and regulating the work of procuring and disbursing materials in accordance with inventory and manufacturing plans.

Inventory Turnover Ratio: The amount of usage, disbursements, or sales of materials, supplies, or products, during a period of time, divided by the average inventory of the particular items during the same period. The amounts may be expressed in terms of dollar values or physical units.

Jig: A movable device for holding a piece of work in proper relation to the tool of a machine.

Job: A term that is used in this book to mean a general work assignment.

Job Analysis: Any technique for collecting, classifying, and analyzing information concerning the characteristics and requirements of general work assignments.

Job Evaluation: Any objective technique for determining the relative functional worth of a job in a classification or hierarchy of jobs, and its corresponding monetary worth. It is a research technique rather than a bargaining technique. The results of job evaluation may be used in collective bargaining, of course.

Job Specification: A concise summary and statement of job analysis information pertaining to the functions, conditions, and requirements of a particular general work assignment, including the requirements that the man for the job should meet.

Journeyman: One who has acquired the basic operative skills and knowledge of a craft, and is competent to apply them under general direction.

Labor, Degradation of: The tendency of mechanization to reduce the social and economic status of displaced craftsmen.

Labor, Elevation of: The tendency of mechanization to increase the social and economic status of unskilled and semiskilled operatives with a consequent increase in their living standards.

Labor Relations, Business: That field of personnel management which deals with the relations between the personal interests of employees, the service objectives of the business organization, and the personal interests of the owners of the business.

Labor Requirements Program: A statement of the number of employees, by labor classes, that will be required to man each department during designated future time periods. See *Employment Program.*

Labor Turnover Ratio: A measure of the rate of separation of employees from the organization, or some component part of it.

Labor Union: An organization of operative employees whose leaders are elected by and from their own number for the purpose of collective bargaining with employers, and for such other legitimate purposes whose accomplishment will promote the interests of the employees.

Labor Utilization Ratio: The standard hours of work produced or shipped divided by the corresponding clock hours, adjusted for production efficiency.

Lead Time: The quantitative amount of time that is required between the initiation of an activity and its completion. A certain part, for example, may have a two months lead time on the end of the assembly line. The term is largely synonomous with "float time."

Leader, A: May be anyone who accepts responsibility for the accomplishment of group objectives, and can gain the support of his group to this end. He may be a superior or an inferior leader under this definition.

Leadership: The work of leaders is management. Leadership is a force that stimulates and motivates the members of an organization in the accomplishment of group objectives. The effectiveness of the work of management is a function of this leadership force times the organizational distance through which its influence is felt.

"Lifo": An accounting term that is used in connection with a value control of inventories. It means "last-in-first-out."

Management: That mental work, or function, of executive leadership which has to do largely with planning, organizing, and controlling the work of others in the accomplishment of objectives.

Management, Administrative: Administrative Management is chiefly group management. It is concerned chiefly with planning, organizing, and controlling the work of organizational groups, or components, over a period of time.

Management, Operative: Operative Management is chiefly project manage-

ment. It is concerned with planning, organizing and controlling the work of executing a project, or some phase of it.

Management, Organic Functions of: Those basic leadership functions that must be performed in or for the organization. Otherwise, it ceases to function economically and effectively. These functions are creative planning, organizing, and controlling.

Management, Scientific Business: An advanced form of management which seeks to apply a sound logic of reflective thinking to business facts and management principles in the solution of some business problem.

Management, Top: A term that is used frequently to refer to the top echelons of general administrative management. These are the echelons of the chairman of the board, the president, the executive vice-president, and those executives who report directly to them.

Manual, Organization: A set of organizational specifications for the principal components of an organization. It states for each component the name of the particular group, its organizational symbol and location, the title of the executive head, the principal organizational subdivisions of the component, and other information concerning objectives, duties, responsibilities, authorities, and organizational relationships.

Manufacturing, Continuous: That type of manufacturing in which labor and equipment are applied continuously to materials for an extended period of time. This period is frequently the manufacturing year.

Manufacturing, Interchangeable: Any system of producing parts and subassemblies that are identical with one another for purposes of the mechanical assembly of a product. The substitution of any part for another piece of the same part will not affect the functioning of the assembly within the limits of service that have been specified for it.

Manufacturing, Intermittent: That type of manufacturing in which labor and equipment are applied continuously to materials for a relatively limited period of time. A "job shop" is a typical example.

Marketing, Industrial: Those functions of an industrial establishment that enter directly into the distribution of its goods or services to its customers.

Master Plan of Work: See *Operation Layout Sheet.*

Materials Handling: An operative function that is concerned, in a manufacturing plant, with the internal movement and positioning of materials and work-in-process, at a particular location.

Materials Handling Systems, Design of: A function of selecting equipment and designing systems for the economical and effective movement of particular materials or work-in-process. It is a function of process planning in a manufacturing plant.

Mechanization of Work: The result of a transfer of skill and knowledge from men to machines. It is accompanied usually by a greater application of power to the machine.

Medicine, Industrial: The theory and practice of medicine, applied to the purpose of preventing and alleviating sickness and injury among industrial workers, in order that they may enjoy the benefits of continuous, productive employment.

Method: See *Procedure.*

Methods Analysis: Any technique for investigating the general requirements for the effective, economical operation of a procedure.

Micro-Motion Study: A technique that employs motion picture photography, making it possible consequently to observe, record, and analyze the unit motions that are used in performing a piece of work together with the conditions immediately surrounding this work.

"Middle Management": The term is largely synonymous with major operative management.

Morale: A mental condition of individuals or groups that determines their attitudes and limits the degree of their acceptance of leadership.

Morale or Attitude Surveys: Any fact-finding, fact-collecting, and analytical technique that obtains and evaluates information concerning the attitudes of individuals and groups. The intent is to determine the level of morale within the organization to which they belong.

Motion and Time Study: A technique for investigating and analyzing the requirements for an effective, economical performance of a step or operation in an operative procedure.

Motion Study: A technique for the investigation, analysis and study of the movements made by an operative in doing a piece of work.

Motion, Unit: A single, continuous movement of some working element of the human body that has definite starting and stopping points.

Objective, An: May be any value for which someone is willing to make the necessary effort or sacrifice to get it. The value may or may not be socially desirable. The objective is the starting point of our thinking concerning any organizational activity.

Objectives, Collateral: Those values that the organization is expected or required to supply to individuals or groups other than customers or the organization itself. These fall broadly into two categories; personal and social.

Objectives, Primary Service: Those values whose creation and distribution constitute the primary mission of the particular organization. The primary objectives of the business organization are those economic values with which it serves its customers. They are salable values for the most part.

Objectives, Secondary: Values that the organization or its components need to enable its personnel to accomplish the mission of the group. These are the immediate objectives of staff departments.

Office Management, Industrial: A staff function that assists other staff offices in planning, organizing, or controlling their operative functions, as requested or required.

Operation, An: A combination or grouping of elementary operations that constitutes a distinct sequential step in the work of accomplishing a project. It may be any series of acts, performed either by one workman or by a group as a unit, that adds one step to the complete process or in itself constitutes a complete process.

Operation, Elementary: A combination and grouping of unit motions that constitute a distinct phase or division of an operation. An operation element

has definite starting and stopping points. In the case of stop-watch studies, it includes the fewest number of motions that can be timed accurately when the eye is the observing instrument.

Operations Research: A scientific method of providing executives with a quantitative basis for decisions regarding the operations under their control.

Operation Layout Sheet: A form for collecting and recording the basic information, concerning product and process, that is necessary for manufacturing purposes. This information should be in a form that will facilitate its use by the production control department and the production line organization. This form may also be known as a "Master Plan of Work," "Routing Sheet," or by some similar term.

Order, Asset: One that authorizes work which increases the capital value of the plant or its offices. The cost of the work adds to the value of the company's fixed assets.

Order Control: A type of production control that is applied to the control of the progress of an order or lot of work through the successive operations and departments in its processing. It is found commonly in plants engaged in intermittent manufacturing.

Order, Expense: One that is issued for work in connection with the repair and maintenance of plant and equipment, or for other work whose cost can not be charged directly to a production order.

Order, Operational: One that authorizes action.

Order, Technical: One that authorizes the use of specified methods and standards for a designated purpose under specified conditions. A technical order does not authorize action.

Order, Production: One that authorizes the manufacture of a given quantity of a particular component part or assembly. It is used commonly with an order control under conditions of intermittent manufacturing.

Organization, An: A group of individuals who have been implemented and trained to some extent for their assigned tasks, and are coöperating to a common end, with some degree of effectiveness, under the guidance of a leader. This definition says nothing as to whether the organization is good, bad, or indifferent.

Organization Chart: A graphic or semigraphic presentation of certain information concerning functions, functional groupings, and lines of responsibility, authority, accountability in the organization.

Organization, Line: A hierarchy or chain of functions, people, responsibility, and authority that leads directly to the creation or distribution of primary values. A line organization develops because of some necessity for a greater division of labor and specialization in the creation or distribution of salable goods or services.

Organization, Staff: A hierarchy or chain of functions, people, responsibility, and authority that leads directly to the provision of collateral or secondary values. It is an evolution from a line organization, primarily for the purpose of managerial specialization and division of labor.

Organization Structure: A structure of relationships between similar func-

tions, physical factors, and personnel that is set up to facilitate the accomplishment of some mission. Its purpose is to promote coöperation and facilitate an effective exercise of executive leadership.

Organizing: The work of creating in advance the basic conditions that are a prerequisite for a successful execution of a particular plan.

Personal Service Record: A history of the employee's service with the company that is sufficient to supply a basis for executive decisions concerning problems affecting the employee personally.

Personnel Management, Staff: That staff function of management which assists line and other executives in the procurement, development, and effective use of people for the accomplishment of the organization's mission. It includes, therefore, the development and maintenance of proper relations between the interests of individuals and groups and the interests of the organization of which they are a part. Personnel management, in business, includes some important staff duties and responsibilities for planning and organizing for the use of the human factor in the work of serving customers.

Philosophy, A Business: A system of thought that relates business objectives, principles, functions, factors, and general methods of attack in a manner that facilitates problem-solving thought. It is, therefore, the basis of effective thinking and successful action.

Physical Minimum: A term used frequently to mean a minimum quantity of a certain material below which the store room is in imminent danger of a critical shortage. It represents the danger point below which the inventory of the material should not be permitted to drop.

Pilot Plant: One in which a modified or new product is manufactured under simulated production conditions. The objective is an opportunity to try out and check in advance new tooling, production standards, operational balance, training requirements, and other factors in effective, economical operations.

Plan, A Business: A basis of action for the solution of some business problem. It is a specification of the factors, forces, effects, and relationships that enter into and are required for the accomplishment of a designated objective. Plans may be managerial or operative.

Planning, General Administrative: The work of determining bases of action for the organization as a whole and its principal divisions, leading to the accomplishment of general organizational objectives. It is concerned largely with long-range planning.

Planning, Creative: The work of determining and specifying originally, the factors, forces, effects, and relationships in the accomplishment of designated objectives.

Planning, Process: Process planning determines how the required quality attributes can be built into the product at a cost that we can afford to pay. It includes the determination of the physical factors and conditions that are required for an effective, economical method for making a product or its component parts. This function is called, variously, process engineering, manufacturing engineering, methods engineering, or industrial engineering.

Planning, Product: The determination of the attributes that the product should have to accomplish its mission of customer service. It requires coöperation between the primary divisions of the manufacturing establishment, as well as marketing research and engineering research.

Planning, Routine: That function of control that makes a routine provision of information concerning a particular plan, and the requirements for an economical, effective execution of it. Routine planning makes a secondary or routine determination of what should be done, how and where it should be done, and who should be responsible.

Planning, Sales: The work of determining bases of effective action for the sales division.

Plans, Intermediate: Intermediate plans are those that cover usually a period from one to five years in the immediate future. Their development is influenced greatly, in some industries, by our estimates of our position in the current business cycle.

Plans, Long-Range: Long-range business plans are those that are based on extensions of secular trends of the business, and our economy, into the future. Such plans usually cover a time span of five years or longer.

Plans, Short-Range: Short-range plans are those that cover usually a time-span of one year, or less. Their development is influenced greatly, in many industries, by normal seasonal variation.

Plant Engineering and Maintenance: A technical staff function that renders a specialized service of facilitation chiefly to the line organization of the manufacturing division. It is concerned with maintaining in good condition the plant equipment and working environment in which the organization performs its work. It provides various building and other services that are associated with the plant and its equipment. It is regarded here as a function of process engineering.

Plant Layout: The function of determining the physical relationships between the operations that must be performed on parts and assemblies, and such physical performance factors as plant equipment, storage areas, materials handling equipment, and other facilities. It is a function of process planning.

Plant Location: The function of determining where the plant should be located for maximum operating economy and effectiveness. It involves an evaluation of the influence of the plant site on both human and physical performance factors in the accomplishment of primary objectives.

Policy, Business: A statement of a principle, or group of principles with their supporting rules of action, that conditions and governs the achievement of certain business objectives toward which it is directed. A policy is neither a plan nor a procedure. It enters usually into the formulation of both. It serves as a guide to the thought and action of the organization

Policy Formulation: A function of policy making. It has to do with the selection and statement of the principles and rules of action that are to govern a particular type of activity. It is the first of seven policy-making functions.

Power, (Engineering): An expression representing the time-rate of doing work.

Preparation: That function of control which assures the availability of the

various performance factors and conditions when, where, and as they are needed for the performance of specific project functions.

Principle, A: A principle is a statement, accepted as true in the present state of our knowledge, which sets up a meaningful relationship between cause and effect. A business principle sets up such a relationship between cause (work) and effect (some accomplishment of business objectives).

Procedure: A structure of relationships between complementary functions, physical factors, and personnel, that is set up for the purpose of coördinating and facilitating the accomplishment of the final objectives of a project. A procedure may be line or staff; managerial or operative. Other terms for procedure are "system" and "method."

Process Design: See *Planning, Process.*

Procurement: The work of securing the materials and supplies for production and the conduct of the business. Procurement may be accomplished by manufacture or by purchase. Procurement is a function of supply.

Procurement Planning and Research: See *Research, Procurement and Planning.*

Product-Line, A: A homogeneous group of products that are related to one another logically through similar primary (customer) service objectives.

Product Mix: What is regarded as the composition of our physical sales volume, in terms usually of the normal proportions of the sales of our various product items in the total volume of sales.

Product Planning: See *Planning, Product.*

Product, A Manufactured: The vehicle that conveys to the customer the utilities that enable him to enjoy certain satisfactions of his needs or desires. The product is an end result of an effective, economical execution of certain manufacturing plans for the accomplishment of the organization's objectives.

Product Development, New: Product development, strictly speaking, has to do with creating and refining desirable attributes in the product, after a satisfactory initial product plan has been made. Some people include product planning, both economic and technical, in product development. The functions of product planning and product development have been differentiated in this book.

Production, Manufacturing: An application of men and machines to materials that is being made with some degree of economy and effectiveness for the manufacture of goods.

Production Program: A statement of the amounts of each end item in each product line that must be produced during specific time periods.

Production Standard, Fair Operative: A standard rate of performance for an operation or larger undertaking that can be met continuously, over an extended period of time, without detriment to the health or well being of the employee.

Profit: A reward of capital for the successful acceptance of business risk, in rendering an economic service. It is the principal objective of the business man, but a collateral objective of the business organization.

Profit-Center: A logical grouping of primary functions, together with the required capital and personnel, that is capable of independent operations to

the extent that its principal executive can be held accountable for earning a planned profit on these operations.

Project, A: Any specific undertaking that has definite, final objectives.

Promotion: Any improvement in the status of an employee within his organization, whether executive or operative, with respect to pay, position, prestige, or privilege.

Property, Right of Private: The right of individuals to hold, use, and dispose of property for the benefit of their personal interests, but with due regard for the public interest. It is the source of executive authority and the right of collective bargaining in a free-enterprise economy.

Purchase Follow-Up: The function of assuring the delivery of a shipment of purchased materials, when and where specified.

Purchase Order: A form of contract, when accepted by the vendor, that authorizes him to deliver certain goods or services under the conditions of purchase and sale that are specified in the order.

Purchasing: The function of securing from vendors, or other outside sources, the proper quantities of whatever materials and supplies are wanted by the organization. These items are purchased with due regard for requirements as to the time, place, and rate of delivery; the specified quality; and the lowest price that is consistent with the preceding requirements or others that may be set up.

Purchasing, Speculative: That purchasing which is done with the primary intent to gain a speculative profit.

Quality Attributes: Those characteristics that distinguish one product or service from another, when both are offered to the customer in satisfaction of the same or a similar need. They are the attributes that give the product or service its utility or need-satisfying capability.

Quality Control: The function of assuring that the quality attributes of a product, or some component part of it, conform to certain prescribed standards, and that the relationships between these attributes are properly maintained in accordance with specifications.

Quality Control, Statistical: A technique for the application of methods of statistical analysis to the control of quality.

Rating, Performance: That process during which a time-study analyst compares the performance or effective effort of the operator under observation with the observer's own concept of proper performance, as compared to a bench mark, or reference point.

Rating Scale, Personnel: A device for obtaining a comparative evaluation of those qualities that are necessary for success in a given line of work but are too intangible to be measured objectively. Initiative is an example.

Receiving: The function of properly inducting into the plant all materials received from vendors or other outside sources. It is the work of handling, recording, reporting, and moving incoming materials. It is a phase of the supply function in manufacturing establishments.

Receiving Inspection: That function of technical comparison which determines the degree of agreement between the quality attributes of incoming material

and those that were specified for the material in the purchase order. It is a phase or subfunction of the work of quality control.

Records, Business: A device for the accumulation, classification, and preservation of information in a manner that will facilitate the performance of the particular business functions concerned.

Reports, Business: A report is a statement of fact and/or opinion that is rendered to a responsible authority. Its purpose is to provide the responsible executive with whatever information may be required to carry on managerial functions. Reports may be oral or written.

Requisition, Labor: An authorization and request for the employment section of the personnel department to procure certain personnel for the current needs of a department or other organizational component.

Requisition, Stores: A clerical instrument that conveys written authority for the withdrawal of materials or supplies from stores.

Research, Industrial or Engineering: The function of investigating and analyzing, scientifically, the physical factors, forces, and effects that enter into the development of product and process in industrial establishments.

Research, Market: A function of marketing research that deals specifically with the market itself. It includes the study of market location, customer preferences and buying habits, market potentials and channels of distribution.

Research, Marketing: The function of collecting, classifying, and analyzing marketing facts, the development of logical conclusions from these facts by valid processes of inductive reasoning, and the interpretation of the significances of these facts and conclusions in the marketing process under a given set of circumstances.

Research, Procurement Planning and: A staff function that is concerned with studies and plans-development for purchase procurement, and for the solution of such other problems in the area of supply as may be assigned.

Research, Product: A function of marketing research that deals with the marketing aspects of the product as a vehicle for carrying customer satisfactions. It leads to engineering research. The latter may result directly in the development of new products, however.

Responsibility: The obligation that an individual assumes when he accepts a general work assignment or "job." It is the obligation of the individual to perform properly the functions and duties that have been assigned to him, to the best of his ability, in accordance with the directions of the executive to whom he is accountable. The right that corresponds to this obligation is authority.

Responsibility, Ultimate Unit of: The obligation of an operative employee for the proper performance of the work assignments that constitute his job.

Routing: That phase of process planning which determines where the operations on a part or assembly shall be performed.

Salary: A rate of compensation for a period of time. It is paid without direct regard for the amount of time actually served, or the amount of results achieved, during the period.

Salvage Function: The work of collecting, reclaiming, reworking, and disposing of scrap and waste materials. It includes also a staff responsibility for

the reduction of the amount of such materials that are produced. Salvage is a staff function of supply in manufacturing establishments.

Scheduling: That function of control which determines when or at what rate the principal phases of the plan must be completed to meet the final time objectives of the project or program. Scheduling supplies the "timing" that is necessary for an effective coördination of action.

Science: A body of verifiable facts and principles, in any field of organized knowledge, that have been classified and arranged to facilitate the solution of problems within the particular field.

Shipping: That function which packs and ships products, or other materials, in accordance with instructions from sales, traffic, or other authorizing departments.

Situation, Law of: Effective leadership depends on the executive's ability and courage to face the facts in a situation, interpret the facts properly in the light of the situation's requirements, and follow the course of action that they dictate.

Sociometry: The measurement of attitudes of social acceptance or rejection, through expressed preferences, among members of a social grouping.

Specification, Job: A statement of the general nature, conditions, and requirements of a job, or general work assignment, and the qualifications that the employee should have to perform this work satisfactorily.

Stability, Organizational: That quality of an organization that enables it to adjust itself promptly to personnel losses without serious losses of economy or effectiveness.

Staff: A term for a function or group of functions that has been differentiated from a line hierarchy of functions, at some level, to render some service to the line organization or to other staff groups.

Standards, Business: Criteria that enable us to proportion and relate functions, physical factors, and personnel to business objectives by means of policy. Business standards are necessary for an effective performance of business functions, both managerial and operative.

Stores Function: That function of supply which is responsible for the custody and safekeeping of all inventories of materials or supplies that are not charged directly to some department or order.

Suggestion Systems: A device for soliciting and collecting ideas for improving operating economy and effectiveness from customers or employees of the organization. The suggestions may take the form of complaints, of course.

Supervision: That function of control which evaluates current action while in progress, and assures that execution is taking place in accordance with plans and instructions. It is the only function of control that can lead directly to corrective action while execution is taking place.

Supervision, Unit of Executive: The number of subordinate units of executive responsibility that are suitable for personal direction and supervision by a higher executive. It is represented usually by a group of three to eight or nine subordinate executives.

Supervision, Unit of Operative: The number of units of operative responsibility that are suitable for face-to-face leadership and supervision by a minor super-

visory executive. It is represented usually by a group of ten to thirty operatives.

Supply Function: The work of providing the requisite materials in the proper quantities at the proper time and place, and at the lowest cost consistent with the specified quality. It includes the functions of procurement, maintenance, and disbursement of inventories.

"System": See *Procedure.*

Therblig: The term coined by the Gilbreths for a unit motion. It is merely the name Gilbreth spelled backward.

Time and Duty Study: A technique for investigating general work assignments that emphasizes the time factor in performance. It seeks to increase the proportion of directly productive time in a general work assignment, and to decrease the proportion of indirectly productive or nonproductive time. This technique is an outgrowth of job analysis.

Time-Study: A technique for observing and analyzing the functions that must be performed in completing an operation, and for recording the time taken. It contributes facts that are necessary for the development of standards of condition, procedure, and performance for the particular operation.

Time-Study Cycle: A term for the series of operation elements that compose an operation.

Time-Study Data Relationships, Standard: Any graphic or mathematical relationship for estimating the time requirements for the performance of an operation, operation element, or unit motion, under specified conditions of work.

Tolerances: Broadly, the maximum deviations from a planned course of action that can be permitted without serious risk of failure of the mission. In factory production, the term is usually restricted to the permissible variance of a quality attribute from the engineering specification.

Tool Design: The engineering function which determines the attributes of devices or implements for extending the functions of a machine, and for adapting them to the requirements of a particular operation.

Tools, Small: The implements that are used directly on material by the man or the machine to perform an operation on the product.

Training, Conference Method of: A method of training that seeks to develop greater effectiveness in the members of a group through the joint analysis and discussion of problems in a particular executive field. It assumes that the required knowledge is to be found largely in the combined experiences of the group.

Training, Foremanship or Supervisory: Training in departmental management, or some phase of it, that is intended to make a minor operative executive more effective in his present job. It may fit him for advancement to a next-higher job at the level of operative management. Such training may be given to candidates for supervisory jobs.

Training, Industrial: Any process for developing an understanding of the requirements for an effective, economical application of some organized body of knowledge to the work of the industrial organization, or some phase of

it. It includes the development of the mental and/or manual skills that are necessary for such application. The basis for training is education.

Training, On-The-Job: Training that is given to the employee at his normal work place, using his normal work assignments as training materials and the equipment that is normally supplied for this work.

Training Programs, Executive Cadet: Any programs that provide some opportunity for executive self-development to individuals who are thought to have leadership potentialities but no practical management experience. It may lead to a first executive assignment at a level of minor operative management.

Training Programs, Executive Development: See *Executive Development Programs.*

Treasurer: The principal line executive, usually, in the field of Finance. He is immediately responsible for the provision, custody, and disbursement of funds on proper authority.

Unclassified Material: The term includes all materials or supplies not stocked regularly by the stores department.

Union, A Trade or Labor: See *Labor Union.*

Unit of Issue: The unit, such as pounds or feet, in terms of which materials or supplies are disbursed by our store rooms. The disbursement unit is not necessarily the same as the purchase unit.

Utility, Economic: The capability of a good or service, or some component part thereof, that enables it to satisfy some customer need or desire. The customer must be willing to pay for this satisfaction. This utility must meet customer requirements having to do with time, place, form, and possession. It must conform to marketing and manufacturing requirements with respect to quantity, quality, time, and expense.

Value, A: A value may be any satisfaction of a need or a desire. The value may be legitimate or illegitimate.

Variances: See *Tolerances.* The term "variance" is used commonly in accounting practice.

Wages: A wage may be any tangible compensation that is received by an employee for his services. It is paid for each unit of time actually served.

Work Assignment, General: The specification of the general functions and duties to be performed by an individual in doing certain kinds of work on certain kinds of operations and projects that are normally assigned to him. It is the individual's job. See also *Job.*

Work Assignment, A Specific Operative: An operative project, or a phase of one, given to an operative employee for performance.

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